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Vol. 57

No. 255

THE AMMONITE FAUNA OF THE KIALAGVIK
FORMATION AT WIDE BAY, ALASKA PENINSULA.
PART II. SONNINIA SOWERBYI ZONE
(BAJOCIAN)

By
GERD E. G. WESTERMANN

1969

Paleontological Research Institution
Ithaca, New York
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GERD E. G. WESTERMANN

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THE AMMONITE FAUNA OF THE KIALAGVIK FORMATION AT WIDE BAY, ALASKA PENINSULA PART II. SONNINIA SOWERBYI ZONE (BAJOCIAN)

GERD E. G. WESTERMANN

McMaster University, Hamilton, Ontario

ABSTRACT

The contact between Kialagvik and Shelikof Formations is now drawn at the base of the Callovian regional unconformity; this accords with the original definition and eliminates strong heterochroneity.

The *Sonninia sowerbyi* (Standard) Zone is represented by, below, at least 35 m subgreywacke, greywacke, and mudstone containing the *Eudmetoceras ampletens* assemblage [*E. ampletens* zonule] and, above, 50-100 m dark shales with concretions containing the *Pseudocidoceras* assemblage [*Pseudocidoceras* zonule.] Part of the incompetent shales are often missing due to strike-slip faulting above the *E. ampletens* zonule. The underlying *E. howelli* Zone is separated by 80-100 m poorly exposed, unfossiliferous, and little investigated clastics; the overlying *O. sauzei* Zone is separated by 110-130 m unfossiliferous sandstone and shale.

The *E. ampletens* zonule has yielded *Eudmetoceras* (*Euaptetoceras*) *ampletens* (Buckman), *Docidoceras* (?), *Bradfordia*? (*Praeoppelia*), and *Hebertoxyites* and is accordingly placed in the lower *S. sowerbyi* Zone, *L. discites* Subzone, of the lowermost Bajocian. The *Pseudocidoceras* zonule includes, below, *Sonninia* (*Euhoploceras*), *Eudmetoceras klimakomphalum* (Vacek), and *Docidoceras* s.s. also attesting the *L. discites* Subzone, and, above, abundant evolute *Witchellia* indicating middle to upper *S. sowerbyi* Zone.

The Ammonoidea are placed in 15 genera, none new, 13 subgenera with three new [*Sonninia* (*Alaskoceras*), *Docidoceras* (*Pseudocidoceras*), *Bradfordia*? (*Praeoppelia*)], 30 species with 13 to 20 new of which nine are named [*Partschiceras ellipticum*, *Pseudolioceras costistriatum*, *Sonninia* (*Euhoploceras*) *bifurcata*, *S.* (*Alaskoceras*) *alaskensis*, *Witchellia sutherlandi*, *Docidoceras* (*Pseudocidoceras*) *widebayense*, *D. (P.) camachoi*, *D.?* (*P.?*) *paucinodosum*, *Bradfordia*? (*Praeoppelia*) *oppeliiformis*], and two subspecies [*Pseudolioceras macIntocki fastigiatum*, *Eudmetoceras* (*Euaptetoceras*) *klimakomphalum discoidale*].

About one-half of the Ammonitina genera and subgenera range higher than in Europe. Affinities are closest to Europe and secondly to South America; affinities to the Western Pacific (Western Australia and Indonesia) are weak and could be accounted for indirectly by migration via Europe and South America. All genera are also known from other continents and only *Pseudotoites* is restricted to the Pacific. High faunistic diversity and species distribution suggest a somewhat lower latitude or a lower temperature gradient than at present, or a combination of both factors.

PREFACE

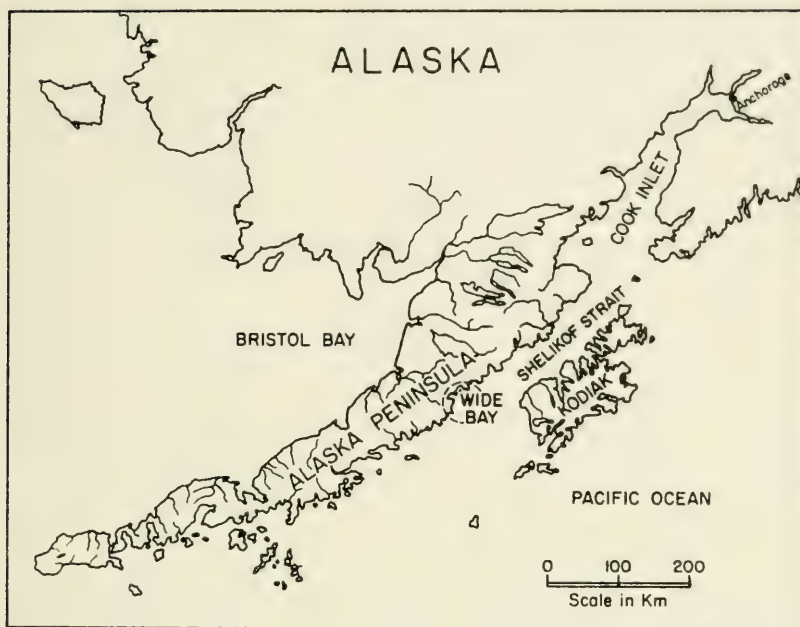
This is the second part of a study of the extraordinarily rich and well-preserved ammonoid fauna from Wide Bay (formerly Kialagvik Bay) comprising the almost universal assemblage of the Bajocian *Sonninia sowerbyi* Zone of the Upper Kialagvik Formation. The first part (Westermann, Bull. Amer. Paleont., vol. 47, No. 216, 1964) dealt with the *Erycitoides howelli* Zone which was correlated with the *Ludwigia concava* Zone of the Aalenian (formerly called Lower Bajocian).

The great bulk of the *E. howelli* fauna was believed to be endemic to Alaska and the western Canadian Arctic until recently

when Sey and Kalacheva (1967) reported the same fauna from the southern coast of the Okhotsk Sea in far eastern Siberia: late Toarcian sandstone with *Pseudolicerias beyrichi* (Schloenbach) are overlain by approximately 480 m siltstones which bear at the base *P. maclintocki* (Haughton) s.s. of early Aalenian age, in the middle part *Erycitoides howelli* (White), *E. (Kialagvikites) spinatus* Westermann, *Pseudolicerias maclintocki whiteavesi* (White), *P. (?)* aff. *P.m. whiteavesi*, and *Inoceramus* sp., and above *Inoceramus* sp. and *P. (?)* aff. *P.m. whiteavesi*. These siltstones pass into 370 m sandstones and siltstones with *Inoceramus* sp., followed by Upper Jurassic beds with erosional unconformity. The *E. howelli* fauna has for the first time permitted the accurate dating of the thick Middle Jurassic terrigenous sequences distributed throughout eastern Siberia. Furthermore, *Tmetoceras* cf. *T. flexicostatum* Westermann has now also been reported from the southern Andes (Westermann, 1967).

While Part 1 of this monograph was in press, the author visited Wide Bay (Text-figs. 1,2) in August of 1964 for two weeks during which 10 days were suitable for field work. Mr. Phillip Hubbard, then a geology student at Oregon State University, assisted in the field. McMaster University and the National Research Council of Canada financed this short expedition. All transportation was by air, with commercial airlines to King Salmon at the eastern end of Bristol Bay and small chartered planes expertly piloted by bush pilots, via Pilot Point at Ugashik Bay to Wide Bay making use of the intertidal slope at Preston Creek (Camp A) and a small air strip of former oil exploration at the mouth of Short Creek (Camp B). After detailed fossil collecting in the *S. sowerbyi* Zone along the sea cliffs east of Camp A, a chartered float plane from Pilot Point moved the Camp to location B on the northwestern side of the bay where the *E. howelli* Zone of the coastal bluffs from Pass Creek to the head of the bay and the important sections along Short and Anderson Creeks were re-examined. Important technical advice and aid were given by Charles Rowett, then at the University of Alaska, R. L. Detterman and T. B. Ball of the U.S. Geological Survey, Alaska Branch, and by M. V. Kirk of Shell Oil Company.

The completion of the second part of this monograph was delayed because of the necessary re-investigation and taxonomic re-



Text-fig. 1.—Index map of south Alaska.

visions of the northwestern European and South American representatives of the almost universal *S. sowerbyi* Zone ammonite assemblages. Particularly the Hammatoceratidae and Sonniniidae have been either in a state of utter taxonomic confusion as reflected in the classification of Buckman (1887-1907; 1909-30: NW Europe), or are poorly known with regard to range variation and affinity (South America). Type specimens were studied in the British Museum of Natural History and in the Geological Survey Museum, London, with the help of M. K. Howarth and F. M. Anderson; the subgenus *Sonninia* (*Euhoploceras*) Buckman was thoroughly revised (Westermann, 1966); the most important classical sections in the southern Andes of Chile and Argentina were re-examined (Westermann, 1967); plastotypes of specimens described in Tornquist's (1898) monograph were kindly sent by H. K. Schmidt, University of Göttingen, and those of Jaworski's (1926) monograph were sent by H. K. Erben, University of Bonn, Germany. Of particular interest were the circum-Pacific genus *Pseudo-toites* Spath and the alleged Australian *Zemistephanus* of which

plaster casts of topotypes were furnished by P. J. Coleman, University of Western Australia, and by R. W. Imlay, U.S. Geological Survey. The author also re-examined in 1963 the *S. sowerbyi* Zone locations of Lupper (1941) in east-central Oregon and Crickmay's (1933) Bajocian section at Mount Jura, California. Plastotypes of the somniniids from the inaccessible old collecting point at Lake Minewanka in the Alberta foothills (cf. Frebold, 1957a) were furnished by D. McLaren and H. Frebold, Geological Survey of Canada.

The author owes sincere gratitude to R. W. Imlay, U.S. Geological Survey, Washington, D.C., for making available to him all fossil collections of the Survey from the *S. sowerbyi* Zone of Wide Bay and also for furnishing the plastotypes of all ammonites described and figured by him. The survey collections (USGS) were made by Walter R. Smith in 1924, S. N. Daviess in 1944, L. B. Kellum in 1943 and 1945, and R. W. Imlay and Don Miller in 1948. A small collection was lent by L. G. Hertlein, of California Academy of Sciences (C.A.S.) in San Francisco, and a few specimens were made available by V. S. Mallory of the Thomas Burke Memorial Washington State Museum, University of Washington (U.W.) in Seattle. M. V. Kirk, Shell Oil Company, who loaned the entire Aalenian and early Bajocian collections of Wide Bay for the first part of this monograph, furnished stratigraphic information (cf. Part I) and polaroid photographs of a number of ammonites from the *S. sowerbyi* Zone. However, most unfortunately, the entire fossil collection had to be returned to Shell Oil Company in 1964 after only a preliminary survey of the *S. sowerbyi* assemblages was completed. The taxonomy of the Hammatoceratidae was fruitfully discussed with E. Elmi, Université de Lyon, and B. Géczy, Museum Korut, Budapest.

Mrs. Gay Walker redrew the text-figures and Miss V. Elkington made the prints from films taken by the author.

STRATIGRAPHY

UPPER BOUNDARY AND CORRELATION OF THE KIALAGVIK FORMATION

The difficulties of correlation and definition of formational contacts caused by strong lateral facies changes are enhanced by

the development of paraconformities with hiati as indicated by fossils and by bedding plane faults which are difficult to detect.

In the first part of this monograph (Westermann 1964a, text-fig. 4 opp. p. 338), I adopted the lithostratigraphic correlation and formational boundaries of Shell Oil Company as communicated by M. V. Kirk, although the alternate position of the formational contact Kialagvik-Shelikof as placed by the U.S. Geological Survey had also been indicated. Without direct knowledge of the exposures I chose to reproduce the results based on the more extensive field work which — as admitted by R. W. Imlay of the U.S. Geological Survey — was that carried out by Shell Oil Company. This correlation resulted in a remarkable alleged heterochroneity of the formational contact transgressing along the NW side of Wide Bay through a lateral distance of only 10 km from the top of the *E. howelli* Zone (Moose Creek — Mt. Kathleen section) to the top of the *O. sauzei* Zone (Mt. Mamie section) and back to the *E. howelli* Zone (Short Creek section) involving a stratigraphic interval of 200-300 m. Along the southeastern side of the bay, the contact was placed within the intermediate *S. sowerbyi* Zone.

Based on my subsequent brief field work at Wide Bay in summer, 1964, I now adhere to the definition and correlation of the formational boundary as originally implied by Capps (1922) and as amended and defined by Kellum, Daviess, and Swinney in 1944 (1945), previous to the more recent mapping by Shell Oil Company (unpublished).

The base of the Shelikof Formation was originally (Capps, 1922) placed at the regional unconformity (locally a paraconformity) developed throughout the "Cold Bay" [Puale Bay] area including "Kialagvik Bay" [Wide Bay], of the terrigenous and tuffaceous beds bearing the Callovian guide fossil *Cadoceras*.

While at Puale Bay the Shelikof lies directly on the Lower Jurassic, a thick Middle Jurassic sequence (Aalenian and lower Bajocian) is present at Wide Bay, which Capps (1922) named the Kialagvik Formation. However, Capps had only visited the northwest side of the bay where the Bajocian (s.s.) is reduced, and he probably did not see the actual contact which is usually concealed, nor was he able to compile a complete stratigraphic section from the isolated exposures (*op. cit.*, p. 95). The upper expanse of the

Kialagvik Formation becomes evident from the described exposures of "sandstones, sandy shale and conglomerate." Besides the *E. howelli* Zone of the bluffs, Capps' Kialagvik Formation also included the *O. sauzei* Zone of location No. 1-113 (10809), about 1 km upstream Caribou Creek at the west end of the bay. Previously T. W. Stanton (in Capps, 1922, p. 96) noted that the *Sonninia* and *Inoceramus* from this locality are "identical with forms in No. 33 of Martin's Tuxedni Bay section" (Martin and Katz, 1912, p. 61: lot No. 33 with "*Stephanoceras*, *Harpoceras*, etc.") [*O. sauzei* Zone] and are younger than the *E. howelli* assemblage. This location is probably identical with location F 20 of Kellum, *et al.* (1945, fig. 2): "Section near Camp 3" which was placed in the "*Inoceramus* sp. C. Subzone." According to Kellum, *et al.* (*loc. cit.*) the sandstone bearing this assemblage [*O. sauzei* Zone] is separated from the "*Hammatoceras* Zone" [*E. howelli* Zone] beneath by an unconformity and about 125 m of poorly exposed beds including, above, grey-green silty sandstones with abundant plant fragments. The "Moose Creek - Mt. Kathleen section" of Shell Oil Company includes Capp's original Kialagvik location No. 1-113 which, however, is placed in the Shelikof Formation, 100-120 m above the formational contact at the top of the *E. howelli* Zone.

Kellum, *et al.* (1945), who carried out a summer's field work in 1944 and produced the geological map of Wide Bay, logically continued Capps' preliminary work and successfully attempted to compile and correlate the three sections of Caribou, Anderson, and Short Creeks. Their placing and correlation of the formational contact appears essentially correct and in agreement with the original definition. In the Anderson Creek section ("Creek near Camp No. 2" of Kellum, *et al.*, "Mt. Mamie section" of Shell Oil Company), the contact was placed similarly by Kellum, *et al.* and Shell Oil Company, *i.e.* above the sandstones of the *O. sauzei* Zone (by Shell Oil Company at top of "*Seymourites* subzone"?). The alleged correlation of the *E. howelli* Zone sandstones of Caribou Creek with the *O. sauzei* Zone sandstones of Anderson Creek as proposed by Shell Oil Company, appears to be due to the stratigraphic approximation of the respective arenite series in the latter section; the intermittent argillaceous sequence has become thinner,

more arenaceous and carbonaceous (Kellum, *et al.* 1945, fig. 2). Shell location No. A 601 (F43) has been re-examined (WA 14) and is now dated as *O. sauzei* Zone, based on the presence of *Parabigotites crassicostatus* Imlay. Shell location No. A 600 (F 42), 10-12 m lower in the section, is poorly fossiliferous, but a single ?*Docidoceras* (*Pseudocidoceras*), based on preliminary identification in 1964, would suggest up to 50-60 m possible *S. sowerbyi* Zone in arenaceous-argillaceous and, below, carbonaceous facies.

In the Short Creek section, 5 km northeast of Anderson Creek, only the *E. howelli* Zone is predominantly arenaceous and conglomeratic. This sequence is overlaid by 30-40 m barren grey shales, well exposed at the steep right bank near the mouth of a tributary. Above follow about 150 m of silty shale with several thick beds of conglomeratic sandstone and lenticular limestone, the lower 50 m of which have now definitely been placed in the *O. sauzei* Zone [L 1062: *Stemmatoceras* cf. *S. triptolemus* (Morris and Lyckett), L 1038: '*Witchellia*' *adnata* Imlay, WA16: *Parabigotites* sp.]; *Inoceramus lucifer* Eichwald ranges almost to the top of this sequence (F4, F24, F25, WM1a) which, therefore, probably belongs entirely in the *O. sauzei* Zone (cf. Imlay, 1955, p. 86). This sequence is conformably overlaid by dark grey shales with diabase sills which have yielded Callovian ammonites at 140-150 m above base [A463, F5] and are probably entirely of Callovian age. The Kialagvik-Shelikof contact is, therefore, at the top of the silty shale and sandstone series of the *O. sauzei* Zone, as placed by Kellum, *et al.* (1945).

The 30-40 m barren shales of the Short Creek section separating the arenite sequences of *E. howelli* and *O. sauzei* Zones may belong in the *S. sowerbyi* Zone. These shales can tentatively be correlated with the poorly exposed argillaceous sequences near the bases of the Caribou Creek and Anderson Creek sections and, perhaps, with the *Pseudocidoceras zonule* (?) and all or part of the overlying unfossiliferous interbedded shales and sandstones) of the southeastern side of the bay.

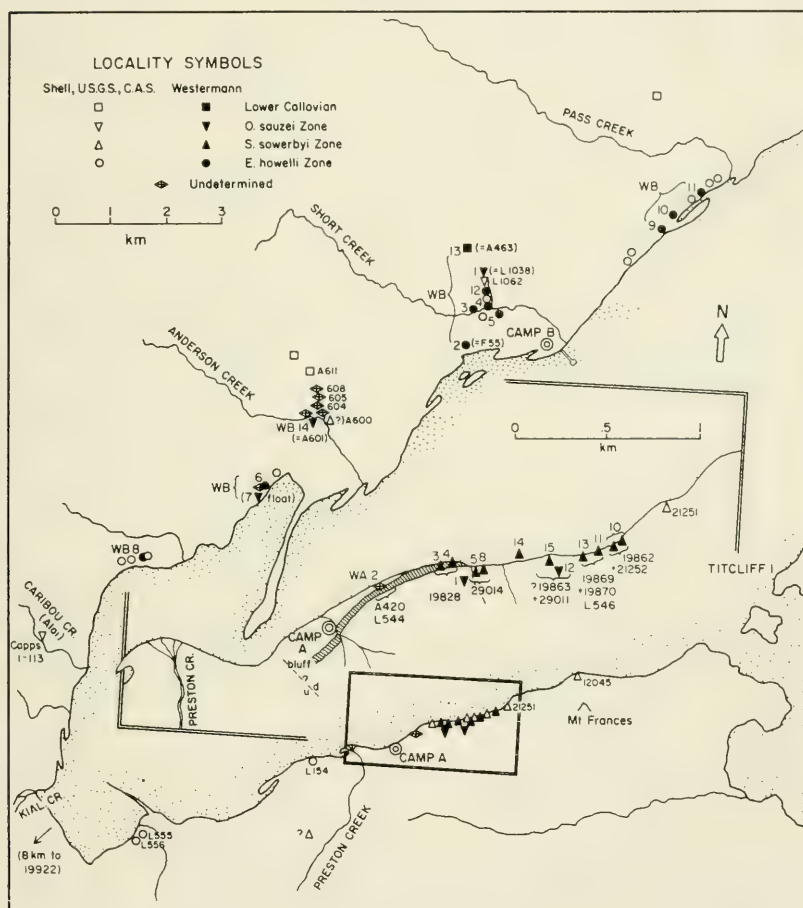
Along the southeastern shore of Wide Bay, east of Preston Creek, the bluffs and cliffs expose from the base (1) 10-20 m unfossiliferous mudstone with some greywacke beds, (2) about 22 m interbedded silty shale and greywacke grading upwards

in massive fossiliferous subgreywacke [*E. amplexens* zonule of *S. sowerbyi* Zone]: (3) 50-60 m (? to 100 m) mostly highly fossiliferous shales with concretions [*Pseudocidoceras* zonule of *S. sowerbyi* Zone] grading upwards into (4) 80-100 m unfossiliferous interbedded sandy shales and sandstones which are topped by (5) fossiliferous subgreywackes with intermittent silty shale [*Parabigotites* zonule of *O. sauzei* Zone]. The *E. howelli* Zone emerges immediately west of Preston Creek but crops out below sea level eastward. The small cape just west of the mouth of Preston Creek which forms the base of a high bluff (Shell loc. L 154) belongs to the *T. tenue* zonule, formerly *T. tenue-flexicostatum* zonule of the highest *E. howelli* Zone, lower horizons of which are exposed in the shore cliff at the western end of the Bay (Shell locs. L 555, L 556). However, Shell location L 154 in the *E. howelli* Zone and my locations WA 3 and WA 4 which yielded the lowest probable *S. sowerbyi* Zone faunules are stratigraphically separated by about 80-100 m unfossiliferous terrigenous sediments, so that the position of the zonal boundary is unknown.

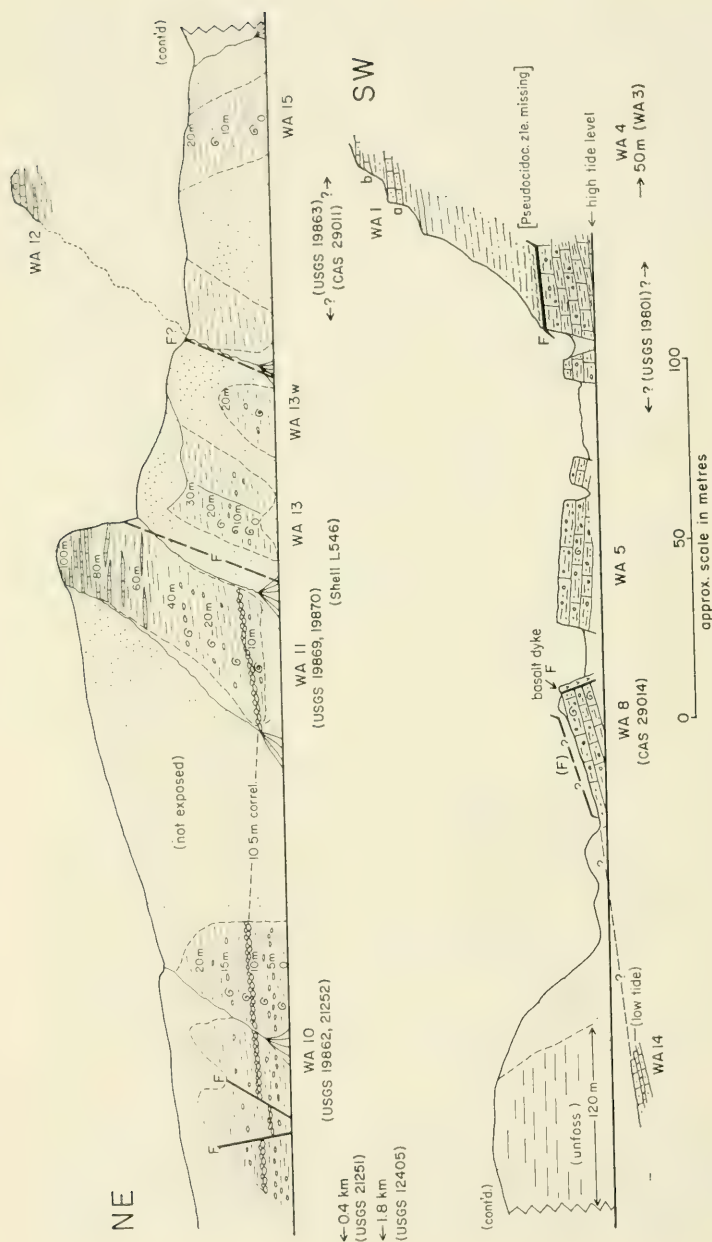
At least most of the bluff west of Preston Creek is roughly equivalent to the bluffs along the northwestern shore of Wide Bay, including the base of the Caribou Creek section, while the bluff of the *E. amplexens* zonule east of Preston Creek seems unrepresented at the other side of the bay. The *Pseudocidoceras* zonule may be equivalent to the 30-70 m argillaceous beds overlying the *E. howelli* sandstones at the northwestern side of the bay. The *Parabigotites* zonule and probably also at least part of the underlying interbedded sandstone-shale sequence belong to the "*Dactylocoeras-Inoceramus* sp. C. Zone" [*O. sauzei* Zone] of Kellum, *et al.* (1915) which they believed to be the most persistent zone in the Wide Bay area. This forms the upper thick arenaceous complex of the Kialagvik Formation.

However, Kellum, *et al.* (1945, p. 7; diagrammatic section on map B) wrongly correlated the southeastern shore exposures with the better known sequence of the other side of Wide Bay. The "sea cliffs . . . from 3½ miles from the end of the peninsula . . . all the way to the end of the bay and . . . continuing . . . in the mountain front beyond to the head of the valley", believed to represent the "*Dactylocoeras-Inoceramus* sp. C. Zone", belong in

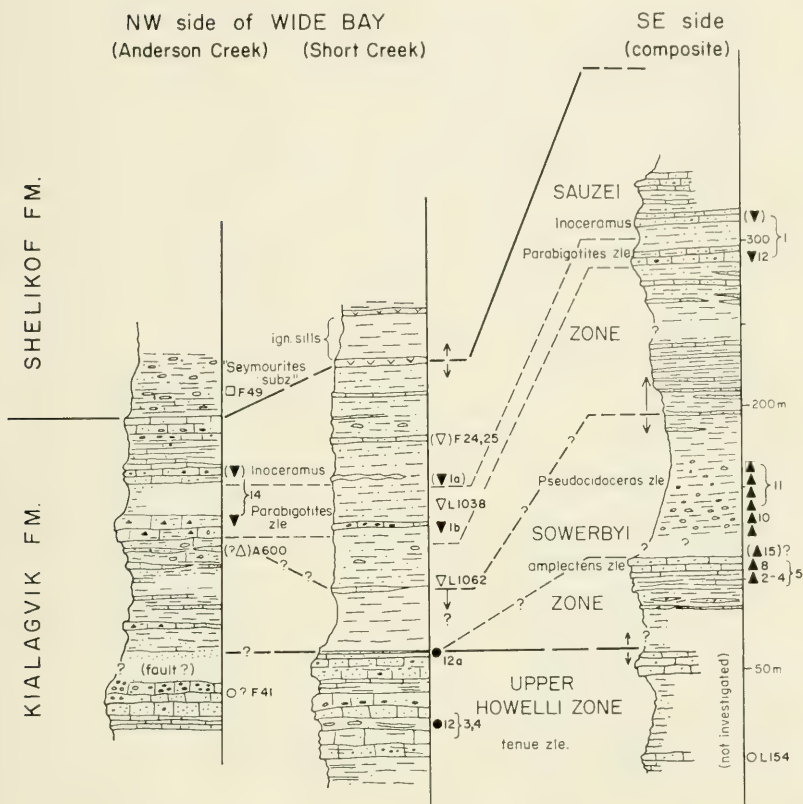
the northeast to the lower *S. sowerbyi* Zone and in the southwest to the upper *E. howelli* Zone. In their diagrammatic section, the Kialagvik-Shelikof contact was drawn at the top of the *Pseudocidoceras* zonule but on their geologic map at the top of the *E. amplexens* zonule and, southwest of Preston Creek, probably near the top of the *E. howelli* Zone.



Text-fig. 2.—Index map of fossil localities at Wide Bay; U.S. Geological Survey: 5-digit numbers and prefix F, Shell Oil Co.: prefixes A and L; author: prefixes WA, WB and bold numbers. Enlarged ($\times 3.2$) insert of SE. side of Wide Bay, drawn from air photograph; with *S. sowerbyi* Zone localities and outcrop of *E. amplexens* zonule (shaded) indicated.



Text-fig. 3. — Sketch of the SE. shore cliffs of Wide Bay, from 1.5 km to 2.5 km east of the mouth of Preston Creek, showing schematically the outcrops of the *S. sauzerbyi* Zone (WA 1 and 12; *O. sauzerbyi* Zone) with location numbers, principle ammonite occurrences and measurements of the sections (cf. left half of Pl. 1).



Text-fig. 4.—Tentative correlations of the upper Kialagvik Formation between the Anderson Creek and Short Creek sections at the northwest side (part. Kellum, *et al.*, 1945) and the SE. side (composite) of Wide Bay. The important fossil localities, formational contacts, ammonite zones and zonules are indicated.

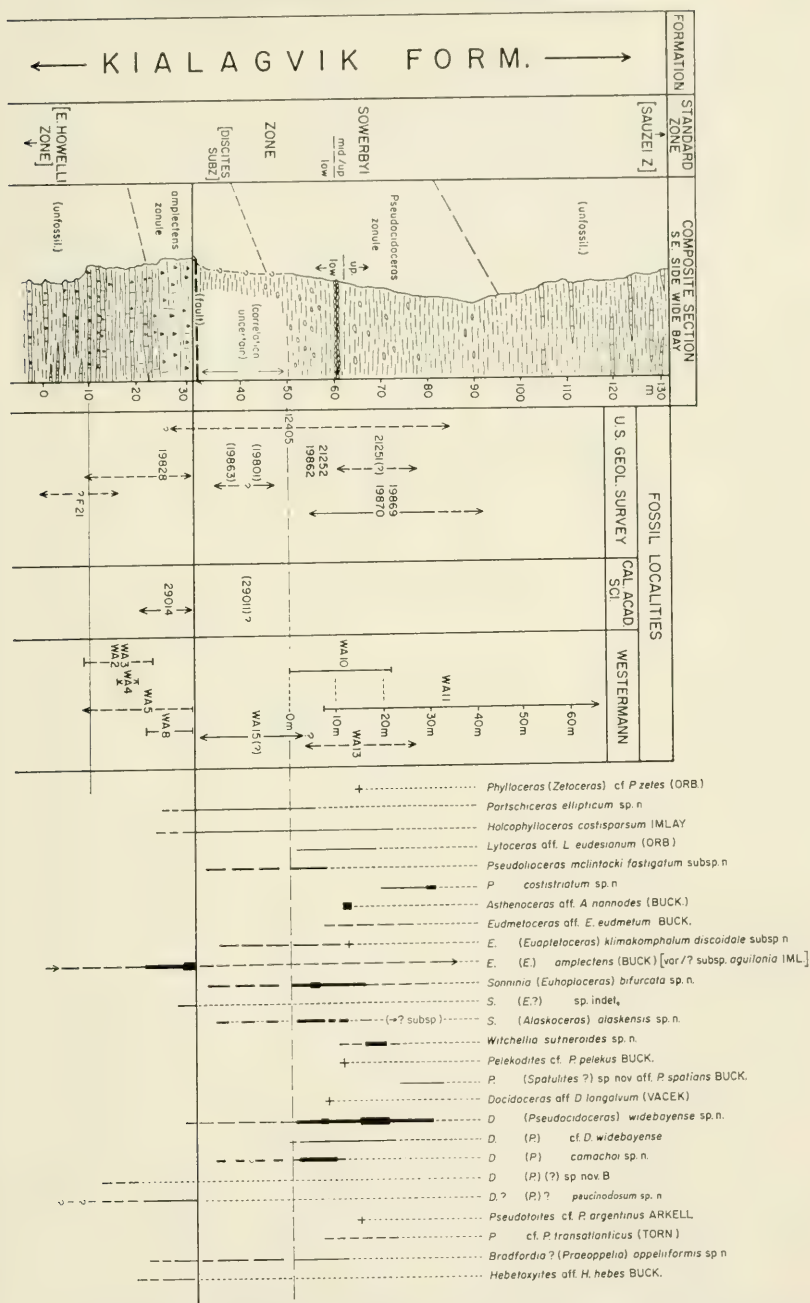
BIOSTRATIGRAPHY OF THE KIALAGVIK FORMATION

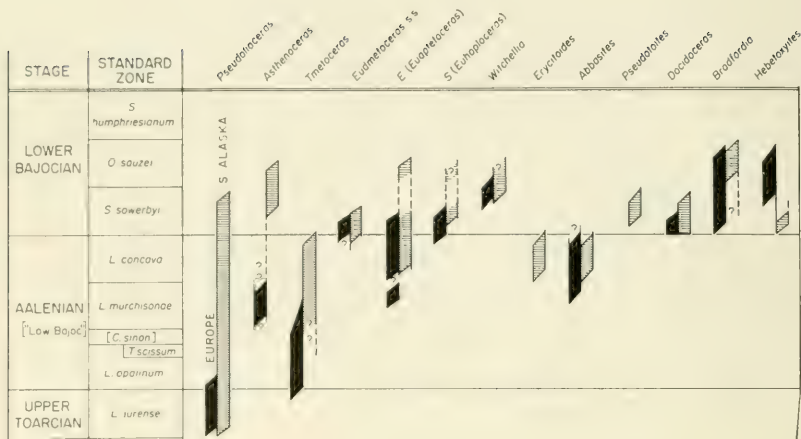
ERYCITOIDES HOWELLI ZONE

The results of my brief field work in 1964 (Text-figs. 2-9) are consistent with the faunal sequences as reported from the Kialagvik Formation along the northwestern side of Wide Bay in the first part of this monograph (Westermann, 1964a, p. 339 ff.). The thicknesses of the faunal zonules and their intervals are confirmed for the Short Creek and Caribou Creek sections except for the *E. howelli* zonule which now appears somewhat thicker. How-

	U.S. Geology Survey								C.A.S.		Shell	U.W.	Westermann										
	12405	19801	19828	19862	19863	19869	19922	21251	21252	29011	29014	546	WA 111	(Lot 37)	WA 3	WA 4	WA 5	WA 8	WA 10	WA 11	WA 13	WA 13w	WA 15
<i>Phylloceras</i> (<i>Zetoceras</i>) cf. <i>P. zetes</i> (ORB.)																			1				
<i>Partschiceras ellipticum</i> sp. n.				2					1								1	2					
<i>Holcophylloceras costisparum</i> IMLAY				1				1									1	1					
<i>Lytioceras</i> aff. <i>L. eudesianum</i> (ORB.)																			3	2	1	1+	
<i>Hebetoxylites</i> aff. <i>H. hebes</i> BUCK.																	1	1					
<i>Bradfordia</i> ? (<i>Pracoppelia</i>) <i>oppeliiformis</i> subgen. et sp. n.				1	4				1	4													
<i>Pseudolioceras macintocki fastigatum</i> subsp. n.	4	1		1					1	2			1						1				3
<i>Pseudolioceras costistriatum</i> sp. n.				1																4			
<i>Asthenoceras</i> aff. <i>A. nannodes</i> (BUCK.)																							
<i>Eudmetoceras</i> (s.s.) aff. <i>E. eudmetum</i> BUCK.								2															
<i>E. (Euaptetoceras)</i> <i>klimakomphalum discoidale</i> subsp. n.	4				2			?												1			1
<i>E. (Euaptetoceras)</i> aff. <i>E. nucleospinosum</i> WEST.	1																						
<i>E. (Euaptetoceras)</i> <i>amplectens</i> (BUCK) [? Var./subsp. <i>aguilonia</i> IMLAY] ..	1															(1)	2	9+					
Cf. <i>Eudmetoceras</i> s.l. indet. [♂]																			1				
<i>Planammatoceras</i> (<i>Pseudammatoceras</i> ?) aff. <i>P. benneri</i> (HOFFM.)								1															
<i>Sonninia</i> (<i>Euhoploceras</i>) <i>bifurcata</i> sp. n.	8			1		3		1											6			13	5
<i>Sonninia</i> (<i>Euhoploceras</i> ?) sp. indet.																	2						
<i>Sonninia</i> (<i>Alaskoceras</i>) <i>alaskensis</i> subgen. et sp. n.	3																		5		1	2	3
<i>Witchellia sutneroides</i> sp. n.	2					1	1	3											2	1+	1	1	
<i>Pelekodites</i> (s.s.) cf. <i>P. pelekus</i> BUCK.																				2			
<i>Dodicoceras</i> (s.s.) aff. <i>D. longaleum</i> (VACEK)																			1				
<i>D. (Pseudodicoceras)</i> <i>widebayense</i> subgen. et sp. n.	5	1		7		4	5+												6	3	6		
<i>D. (Pseudodicoceras)</i> cf. <i>D. widebayense</i>		1		1			(1)												1	1	1		
<i>D. (Pseudodicoceras?)</i> aff. <i>D. widebayense</i>																			2				
<i>D. (Pseudodicoceras)</i> <i>camachoi</i> subgen. et sp. n.	4	1		1	1		5			3									8	2		1	
<i>D. (Pseudodicoceras)</i> sp.n. A	1			1																			
<i>D. ?</i> [<i>Pseudodicoceras</i> /subgen. nov.] sp.n. B.															1								
<i>D. ?</i> (<i>Pseudodicoceras?</i>) <i>paucinosum</i> subgen. et sp. n.			2							1							3						
<i>D. (Trilobiticeras?)</i> sp.n. indet.												1											
<i>Pseudotoites</i> cf. <i>P. argentinus</i> ARKELL	1			1			1												1				
<i>Pseudotoites</i> cf. <i>P. transatlanticus</i> (TORNQ.)				1				1															

Text-fig. 6.—Occurrences of ammonite species from the *S. sawyerbyi* Zone of Wide Bay; numbers of identified specimens indicated. Localities of the U.S. Geological Survey (U.S.G.S.), California Academy of Sciences (C.A.S.), Shell Oil Company (Shell), University of Washington (U.W.), and of the author.





Text-fig. 8.— Comparison of the vertical ranges of Aalenian and early Bajocian ammonite genera and subgenera between southern Alaska and north-western Europe. Note the higher ranges of many taxa in southern Alaska.

ever, there is no evidence for the previously inferred thickness increase towards the southwest. No additional fossil evidence is available for the tentative *T. scissum* zonule since the basal c. 100 m of the Kialagvik Formation at Short Creek is now almost totally concealed. The *E. teres* zonule (formerly *E. teres-profundus* zonule) separating lower and upper *E. howelli* Zone, is confirmed in the Short Creek Section (my location WB 5, Kellum, *et al.*, 45 Akm, F12) by abundant *Erycitoides teres* Westermann, which is, therefore, here named as guide fossil for this assemblage. The *T. tenue* zonule (formerly *tenue-flexicostatum* zonule) at the top of the *E. howelli* Zone is confirmed in the same section (my location WB 12 = USGS 48A - 109) by abundant *Tmetoceras tenue* Westermann, with *T. flexicostatum* Westermann and *T. cf. kirki* Westermann; *T. tenue* is the most distinct species and named guide fossil. Both zonules also bear the zone index *E. howelli*.

SONNINIA SOWERBYI ZONE

The zone contains the *E. amplexens* zonule below, and the exceptionally fossiliferous *Pseudocidoceras* zonule above; both have been clearly identified only along a 4 km strip at the southeastern shore of the bay.

E. amplexens zonule. — The zonule consists of 10-12 m mostly

Stage	Standard Zone	WIDE BAY (Imlay, 1964, Westermann, 1964, here)	NW side of COOK INLET (Imlay, 1964)	Suggested guide fossils for S Alaska (Imlay, 1964, Westermann, here)	
BAJOCIAN	U.	(missing)	Twist Creek siltst.	<i>Megaspheeroceras rotundum</i>	
	L.		Cynthia Falls sandst.	<i>Teloceras itinsae</i>	
	S. <i>humphriesianum</i>		Fitz Creek siltst.		
	O. sauzei	[Inoceramus] <i>Parabigolites</i> zle.	Gaikema sandst.	<i>Skirrocera kirschneri</i>	
	Up. S sauzeyi Mid. Low [discites]	Pseudodocidoceras zle. ? ? amptelens zle. ? ? tenuis zle. Eudimeloceras zle. teres zle.	Red Glacier form.	<i>Parabigolites crassicastratus</i>	
AALENIAN	L. concava	O. sauzei Zone			[?Pseudolac costistratum]
		[Inoceramus] <i>Parabigolites</i> zle.			<i>Docidoceras widebayense</i>
		Pseudodocidoceras zle.		[Witchellia sulneroides]	
		? ? amptelens zle.		[Docidoceras comacho]	
		? ? tenuis zle.		[D? paucicostatum]	
		Eudimeloceras zle.		<i>Tmeloceras tenue</i>	
		teres zle.		<i>Erycitoides howelli</i>	
		[T. scissum]		<i>Erycitoides teres</i>	
				[Tmeloceras scissum]	

Text-fig. 9. — Correlation table for the Aalenian and lower Bajocian ammonite zones and zonules of southern Alaska.

massive subgreywacke and yields abundantly *Eudmetoceras* (*Eupatetoceras*) *amplectens* (Buckman) [incl. var. or subsp. *aguilonia* (Imlay)], moderately common *Docidoceras* ? (*Pseudocidoceras* ?) *paucinodosum*, n. sp., and scarce cf. *D. (P.) widebayense*, n. sp., *Bradfordia*? (*Pracoppelia*) *oppeliiformis*, n. sp., *Hebetoxyites* aff. *H. hebes* Buckman, *Sonninia* (*Euhoploceras*?) sp., and phylloceratids. This is the "acme-zone" of *E. amplexens*, but the species ranges into the *E. howelli* Zone below, and into the *O. sauzei* Zone above. The only common species which appears to be restricted to this zonule is *D. paucinodosum* which could, therefore, be considered as guide fossil. The Otoitidae, Oppeliidae, and the strigoceratid *Hebetoxyites* attest to a Lower Bajocian [post-*L. concava* Zone] age; the common *E. amplexens* and the stratigraphic position below the *Pseudocidoceras* zonule, yielding early *Sonninia* and *Docidoceras* s.s., restrict the age correlation to the lower or basal *S. sowerbyi* Zone, approximately to the (European) *Ludwigia discites* Subzone.

Although the massive character of the subgreywackes (? and greywackes) and the apparent random orientation and poor preservation of most ammonite shells suggest submarine slumping or similar processes of mass-wasting, there is no paleontological evidence for significant stratigraphic mixing of the faunas. The common *Eudmetoceras amplexens* are usually strongly corroded, fractured, and often fragmented which could be due to reworking; allochthony would be consistent with the known occurrence of this species in the underlying *E. howelli* Zone. The other ammonites, all unknown from the Aalenian, are much better preserved and, therefore, almost certainly autochthonous. However, even under the assumption that the *E. amplexens* are reworked, the *E. amplexens* zonule is to be placed in the lower part of the *S. sowerbyi* Zone because of the superimposed *Pseudocidoceras* zonule.

Pseudocidoceras zonule. — The zonule consists of at least 40 m (? to 80 m) shales with calcareous concretions which probably are separated from the *E. amplexens* zonule by 10 - 20 m unfossiliferous shales. This incompetent interval has been structurally reduced or totally suppressed wherever the competent *E. amplexens* zonule is exposed and the contact lies below sea level where the sequence appears complete. Thus, all or part of the structurally

isolated 20 - 30 m shaley section of locality WA 15 apparently belongs at the base of the *Pseudocidoceras* zonule. This zonule bears without doubt the richest, most diverse and best preserved known ammonite assemblages of the *S. sowerbyi* Zone in North America, and possibly of anywhere but a few localities of Europe. However, the fossiliferous exposures known in 1964 were restricted to only 350 - 400 m length of the shore cliff along the south side of the Bay (from loc. WA 10 to loc. WA 15; old locs. 21251 and 12405 were concealed or destroyed in 1964).

The zonule includes several ammonite assemblages in overlapping succession. However, horizontal variation being unknown, the apparent faunistic changes could be due to differences in biofacies, *post-mortem* drift, and preservation. Nevertheless, the observed vertical ranges are probably of more than local significance because (1) lithofacies varies little throughout the zonule, (2) ranges vary greatly from species to species with frequent overlaps, and (3) there are certain resemblances in the ammonite succession with other areas.

A two-fold faunistic subdivision of the zonule is strongly apparent. The lower part contains abundant *Sonninia* (*Euhoploceras*) *bifurcata*, n. sp., *S. (Alaskoceras) alaskensis*, n. subgen. and n. sp., *Docidoceras* (*Pseudocidoceras*) *camachoi*, n. subgen. and n. sp., *D. (P.) widebayense*, n. sp., *Pseudolioceras macklintocki fastigatum* n. subsp., and the less common *Bradfordia?* (*Pracoppelia*) *oppelii-formis*, n. subgen. and n. sp., and *Eudmetoceras (Euaptetoceras) klimakomphalum discoidale*, n. subsp.; all are essentially restricted to this part except for *D. widebayense* which ranges throughout the zonule. The upper part bears abundant *Witchellia sutneroides*, n. sp., *D. (Pseudocidoceras) widebayense*, n. sp., and, especially at the top, moderately common *Pseudolioceras costistriatum*, n. sp. Other ammonoids such as Phylloceratidae, *Lytoceras*, *Eudmetoceras*, *Pelekodites*, *Docidoceras s.s.*, and *Pseudotoites* are scarce throughout the zonule so that their ranges cannot be established and *Asthenoceras* was found only in a "nest," i.e. a single concretion, in the middle of this interval. A third assemblage may be present at the poorly known apparent base of the zonule (locs. WA 15, ? USGS 19801, ? USGS 19863, ? CAS 29011) which yields only a few *D. (Pseudocidoceras)* and the common *S. (Euhoploceras)*, *S. (Alasko-*

ceras), *Pseudolioceras*, and *B.?* (*Pracoppelia*). The only other common larger fossils are clusters of *Inoceramus lucifer* Eichwald and fragments of wood and leaflets.

The lower assemblage, for which *D. (Pseudocidoceras) camacho* is chosen as guide fossil, has also furnished near the top a single *Docidoceras* aff. *D. longulum* (Vacek) supporting the correlation of this interval with the *L. discites* Subzone of the lower *S. sowerbyi* Zone. The upper assemblage which is probably best characterized by the evolute *Witchellia sutneroides*, sp. n., belongs clearly in the higher part of the *S. sowerbyi* Zone, equivalent to both or either of the northwest European Subzones of *Sonninia trigonalis* and *Witchellia laeviuscula*; *W. sutneroides* is indeed morphologically intermediate between "*Zugophorites*" Buckman [*Witchellia* subgen.?] of the *S. trigonalis* Subzone and typical *Witchellia* of the *W. laeviuscula* Subzone.

OTOITES SAUZEI ZONE

The ammonoid assemblage of the *Parabigotites* zonule has recently been monographed by Imlay (1964) who has given ample evidence for *O. sauzei* Zone. A number of *Parabigotites crassico-status* Imlay and some *Bradfordia* sp., *Stemmatoceras* cf. *S. triptolemus* (Morris and Lycett), "*Witchellia*" *adnata* Imlay and, significantly, *Eudmetoceras amplexans* (Buckman) [var. or subsp. *aguilonia* Imlay] have been identified from my localities WA 1, WA 12, WB 1, WB 14, and Shell localities L 1038 and L 1062. The *P. crassico-status* zonule is separated from the *Pseudocidoceras* zonule by 80-100 m unfossiliferous arenaceous shales and sandstones. The beds superposed on the *Parabigotites* zonule are almost barren of ammonites, but yield abundant *Inoceramus lucifer* Eichwald which appears to become extinct at the top of the *O. sauzei* Zone (Imlay, 1955, p. 86). The upper *O. sauzei* Zone assemblage with *Skirroceras kirschneri* Imlay from southeast Alaska (Imlay, 1964, p. B7) appears to be absent at Wide Bay, probably because beds of this age are missing under the paraconformity of the Callovian Shelikof Formation.

FAUNAL RELATIONS AND AGES OF THE *S. sOWERBYI* ZONE ASSEMBLAGES

The ammonoid fauna of the *S. sowerbyi* Zone at Wide Bay is in its global relationship essentially European, with an admixture of Pacific elements and a strong regional (endemic) character at the species level. This is evident from the following discussion of the principle areas of development of this assemblage, *i.e.* the North American Cordilleras, the southern Andes, Western Australia—Indonesia, and Europe. The Phylloceratina, represented by *Phylloceras*, *Partschiceras*, *Holcophylloceras*, and the Lytoceratina, represented only by *Lytoceras*, are known to be entirely cosmopolitan and, therefore, omitted from this discussion; it is pointed out that their relative abundance is significantly smaller than commonly attributed to eugeosynclinal environments, particularly at oceanic margins. Of the 11 described Ammonitina genera, one appears to be endemic to North America while a number of the others have here longer vertical ranges than previously known from other continents, which is essentially the European epeiric Jurassic (Text-fig. 8).

NORTH AMERICA

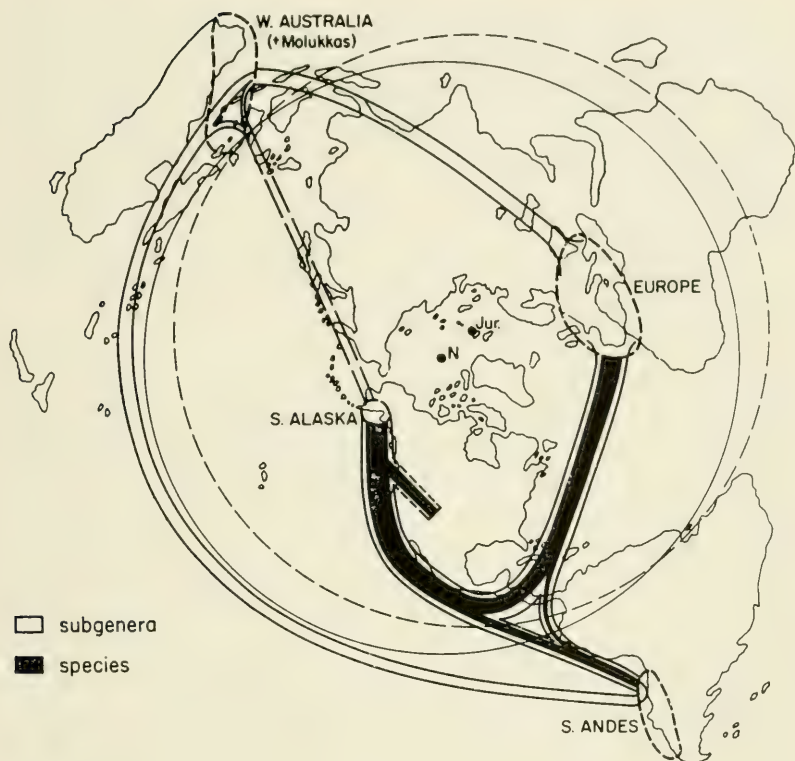
Southeast Alaska.—Surprisingly, there is no good evidence for the presence of the *S. sowerbyi* Zone in Alaska other than at Wide Bay, although the Bajocian is well known from the fossiliferous Tuxedni Group of Cook Inlet (Imlay, 1962, 1964) where the *O. sauzei* Zone seems to follow directly on the *E. howelli* Zone. However, unfossiliferous beds, which could represent the apparently missing zone, are sometimes intercalated in the thick sedimentary sequences.

Imlay (1964) described from the Tuxedni Group of the Talkeetna Mountains several ammonites which are identical with or closely related to species occurring at Wide Bay in the *S. sowerbyi* Zone. *Sonminia* (*Euhoploceras*) *bifurcata*, n. sp. (Imlay, 1964, p. B33, pl. 4, figs. 5, 6, 12; "*Sonminia* ? n. sp. undet."; p. B14), which could possibly belong in the *S. sowerbyi* Zone, and *Witchellia* sp. were described from the "upper half of the lower sandstone." The former species, however, is said to be usually associated with *Emileia constricta* Imlay, such as in the lowest fossiliferous beds

of the Red Glacier Formation of the Iniskin Peninsula (*op. cit.*, p. B14, pl. 4, fig. 10, 11, table 13). *E. constricta* is a close ally of *E. polyshides* (Waagen) and a good indication of the *O. sauzei* Zone. *S. (Alaskoceras)* sp. aff. *S. alaskensis*, n. sp. (*op. cit.*, p. B33, pl. 2, fig. 1, 2; "*Sonninia* cf. *S. nodata* Buckman") occurs in the "upper siltstone" and is said to be associated with *Stephanoceras* (*Skirroceras*) spp., again clear indicators of the *O. sauzei* Zone. *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buckman) [var. or subsp. *aguilonia* (Imlay)] (*op. cit.*, p. B35, pl. 4, figs. 1-4; 9; pl. 5, figs. 4, 7-9; "*Witchellia?* *aguilonia* Imlay, n. sp.") was described from a 60 m interval again yielding the typical *O. sauzei* Zone assemblage, as well as from the *Parabigotites* zonule of Wide Bay. *Planammatoceras* (*Pseudammatoceras?*) aff. *P. benneri* (Hoffman) (*op. cit.*, p. B33, pl. 3, figs. 2-4; "*Sonninia* cf. *S. patella* Waagen"), formerly known from the *L. concava* Zone and *L. discites* Subzone of Europe and here described from the *S. sowerbyi* Zone of Wide Bay, was described from the *O. sauzei* Zone assemblage of the Talkeetna Mountains. However, the alleged *Witchellia* cf. *W. laeviuscula* (J. de C. Sowerby) (Imlay, p. B35, pl. 7) is not a true *Witchellia* of the *W. laeviuscula* group.

Western Canada. — The *S. sowerbyi* Zone is usually absent under paraconform *O. sauzei* Zone or, more frequently, *S. humphriesianum* Zone. The only known exceptions are probably part of the "middle sedimentary division" of the Hazelton Group of Hudson Bay Mountain, west-central British Columbia, and a poorly known horizon in the Fernia Group of "Devils Point" at Lake Minnewanka, Alberta.

The small collection of sonniniids from scree of Hudson Bay Mountain was described by McLearn (1926) and dated as *O. sauzei* to *S. humphriesianum* Zone. However, four of the five new specific names under *Sonninia* and *Guhsania* McLearn were based on single, incomplete, and distorted phragmocones only and are here regarded as *nomina dubia*. *Guhsania bella* McLearn, the type species, has a discoidal, almost oxycone shell, with strong rectiradiate simple costae probably bearing lateral tubercles, and appears to be intermediate between *Sonninia* (*Papilliceras*) and *Fissiloboceras*. "*Sonninia Hansonii*" resembles the Andean *S. espinazitensis* Tornquist; "*S. skawahii*" and "*S. silveria*" may belong to a single species of



Text-fig. 10. — Cosmopolitan affinities of the principle ammonite assemblages of the *S. sowerbyi* Zone of Wide Bay, possibly indicating migration routes; based on numbers of common subgenera and species. Note that the affinities between southern Alaska and Western Australia—Indonesia could be accounted for by migration via Europe and South America, and that the assumption of continental drift would alter the relative position of the Australo-Indonesian area significantly.

Witchellia ("Zugophorites") or possibly partly to *Sonninia* (*Euhoploceras*), resembling the species from Lake Minnewanka and evolve *Witchellia* from the middle part of the northwest European *S. sowerbyi* Zone. *Guhsania bella* and "*Sonninia Hansoni*" could come from a higher level, i.e. the *O. sauzei* Zone. "*Guhsania ramata*" is known from a single small fragment only, resembling *G. bella*.

The long known poorly preserved small "Devils Point" assemblage (Whiteaves, 1889) representing the only good evidence

of the *S. sowerbyi* Zone from Canada, was redescribed by Frebold (1957a, pp. 48-49, pls. 19-20) and is here identified with *Sonninia* (*Euhoploceras*? or *Alaskoceras*?) *gracilis* (Whiteaves), *S. (Euhoploceras)* cf. *S. bifurcata*, n. sp. (*op. cit.*, pl. 20, fig. 1), *S. (Euhoploceras)* sp. (*loc. cit.*, figs. 2, 3), and *Witchellia* ("Zugophorites") sp. (*op. cit.*, pl. 19, figs. 2 a, b).

Western U.S.A. — In northern California, the *S. sowerbyi* Zone is tentatively indicated in the Mormon Formation of Mount Jura, Shasta County, by (?) *Sonninia (Euhoploceras)* "*schucherti*" (Crickmay, 1933, *nom. dub.*)

The next best representation of the *S. sowerbyi* Zone in North America after Wide Bay is in the Supplee area of east-central Oregon. The section was described by Luper (1941) and was re-investigated by Imlay (1964, p. B19) and the author (unpublished), but the fossils have not been described. According to Luper and Imlay, the lower part of the Weberg Formation has yielded *Tmetoceras*, which in its upper range is associated with *Praestrigites* and *Docidoceras*; this association, not verified by this author, would extend the range of *Tmetoceras* into the *S. sowerbyi* Zone. Above follows a rich assemblage of large *Sonninia (Euhoploceras)* sp. and *Witchellia* ("Zugophorites") sp., both strongly reminiscent of the Lake Minnewanka forms but preserved too poorly for specific identification; this assemblage probably also includes sparse *Strigoceras*, *Praestrigites*?, *Docidoceras* s.l., and *Eudmetoceras*?, thus resembling the assemblages of the northwest European lower and middle *S. sowerbyi* Zone. Slightly higher is an assemblage of abundant *Asthenoceras* sp., known in two specimens from the *L. murchisonae* Zone of England and from the *S. sowerbyi* Zone of Wide Bay, with sparse *Witchellia* and *Sonninia (Euhoploceras)*. This is followed by the *O. sauzei* Zone assemblage of the Warm Springs Formation which also contains abundant *Asthenoceras*.

In summary, the other North American assemblages of the *S. sowerbyi* Zone have in common with Wide Bay five to seven genera and at least six subgenera, all of which, however, also occur in Europe; the small number (two to four) of common species is probably due to the poor knowledge of the non-Wide Bay assemblages and specific affinity actually appears to be quite high. Significantly, Bajocian *Pseudolioceras* and particularly the common

respectively typical Pacific and Wide Bay forms *Pseudotoites*,¹ *Docidoceras* (*Pseudocidoceras*) and *Sonninia* (*Alaskoceras*) appear to be absent while the strigoceratids, present in the *S. sowerbyi* Zone of Oregon, make their appearance in Alaska only in the *O. sauzei* Zone. These statements are highly tentative awaiting the monographic study of the Oregon ammonite assemblage. The apparent close affinity of the Oregon assemblage, the only better known assemblage of the North American *S. sowerbyi* Zone except for Wide Bay, to the northwest European epeiric seas assemblages may be owing to ecological resemblance.

SOUTH AMERICA

Southern Andes.—The *S. sowerbyi* Zone appears to be absent in the northern and central Andes (Guiana to Peru), and, contrary to the opinion of Arkell (1954, p. 591; 1956, p. 585) and Imlay (1964, p. B21) the evidence for its presence in the southern Andes is far from excellent although approximately every second genus, every fourth subgenus, and probably several species of the Wide Bay assemblage are found there (Westermann, 1967). In northern Chile and northwestern Argentina three major assemblages are present, stratigraphically above early to middle (?upper) Aalenian beds and below the widespread *O. sauzei* Zone; they have respectively been named after *Eudmetoceras* (?) *gerthi* (Jaworski), "*Pleydellia*" *puchensis* (Burckardt), and *Pseudotoites singularis* (Gottsche) (*op. cit.*).

The *E. gerthi* assemblage has also yielded *Eudmetoceras* (?) *jaworskii* Westermann (1964a), *E.* (?) *kochi* (Prinz), *E.* (*Euaptetoceras*) cf. *E. klimakomphalum* (Vacek), *E.* (*E.*) *klimakomphalum moerickei* (Jaworski) [not *Bradfordia*, with hollow-floored keel] and probably sparse (?) *Sonninia* (*Euhoploceras*) sp., *Zurcheria* (?) sp., "*Fontannesia*" *austroamericana* Jaworski, *Tmetoceras* cf. *T. scissum* (Benecke) and *T.* cf. *T. flexicostatum* Westermann. This assemblage was dated as upper Aalenian by Jaworski (1926) and as basal Bajocian *L. discites* Subzone by Arkell (1956, p. 585); either date or both may be correct, and the possibly somewhat

¹ *Am. carlottensis* Whiteaves, 1876, from the *S. humpriesianum* Zone of south-eastern Alaska and coastal British Columbia, is not a *Pseudotoites* as supposed by Arkell (1954, p. 587; 1956, p. 538, 542) but a *Zemistephanus* (Imlay, 1964, p. B52).

condensed assemblage is now placed at about the Aalenian-Bajocian boundary.

The "*P.*" *puchensis* assemblage consists of closely related species (or a "plexus") of late hammatoceratids, possibly intermediate to early sonniniids, described by Burckhardt (1903) under "*Harpoceras puchense*, n. sp., *H. malarguense*, n. sp., *H. hauthali*, n. sp., *Witchellia argentina*, n. sp., *Harpoceras striatulum* Sowerby and *Harpoceras klimakomphalum* Vacek," as well as of abundant *Witchellia*?, n. sp. indet. and a single nucleus resembling *Sonninia* (*Euhoploceras*) *adicra* (Waagen). This assemblage is only known from west-central Mendoza and may be approximately equivalent in age to the *E. gerthi* assemblage.

The *P. singularis* assemblage overlies the *E. gerthi* assemblage and includes the common *Pseudotoites* (*Latotoites*) *evolutum* (Tornquist), the sparse *P.* (?) (n. subgen.) *sphaeroceroides* (Tornquist) and probably also *P. transatlanticus* (Tornquist), *P. argentinus* Arkell, *Sonninia* ("*Sonninites*") *zitteli* (Gottsche), *S. intumescens* Tornquist and *S. (Papilliceras)* cf. *S. espinazitensis* (Tornquist). This assemblage belongs, therefore, in the upper part of the *S. sowerbyi* Zone or, possibly, at the base of the *O. sauzei* Zone.

While the affinity of the *E. gerthi* assemblage is about equally divided between southern Alaska and Europe, the *P. singularis* assemblage shows additional resemblances to the Australo-Indonesian area. However, the South American *Pseudotoites* species are closer to Alaskan than to west Pacific species and have with the former probably *P. transatlanticus* and *P. argentinus* in common; the Andean *P. singularis* is morphologically intermediate between the typical Australian forms and early *Emileia* ("*Emileites*") of the northwestern European middle to upper *S. sowerbyi* Zone. The associated sonniniids have affinities with Alaskan and, especially, European species but are unknown from the west Pacific margin.

WEST PACIFIC MARGIN

The only well-known larger assemblage of the *S. sowerbyi* Zone is from the Newmarracarra Limestone of Western Australia (Arkell and Playford, 1954); parts of this assemblage have also been identified from the Moluccas and New Guinea, but no good evidence exists for the presence of the zone in eastern Asia. The Australian

assemblage has in common with Alaska three to four genera [*Sonninia*, *Witchellia*, *Pseudotoites*, *Docidoceras* (?)] but only one or possibly two subgenera [the sparse *Sonninia* (*Euhoploceras*) and ? *Docidoceras* (*Trilobiticeras*)], and no species. The assemblage is dominated by the typically European *Fontannesia* [*F. clarkei* (Crick) with syns.] which appears to be absent along the eastern Pacific margin and by several species of the typically Pacific *Pseudotoites*, including the microconchiate *P. (Latotoites)*, some of which are strongly reminiscent of evolute *Emileia* s.s. and *E. (Otoites)* and others of *Docidoceras*, all of the northwestern European *S. sowerbyi* Zone (Westermann, 1964b). This assemblage also includes sparse "coronate cadicones" which were originally identified with the northwestern American stephanoceratid *Zemistephanus* (Arkell, in *op. cit.*) but are in fact closely related to the Andean *Pseudotoites* (?) (n. subgen.) *sphaeroceroides* (Tornquist), as well as a few involute *Witchellia*.

It appears, therefore, that the relationship of the *S. sowerbyi* Zone Ammonitina assemblages between Australo-Indonesia and Alaska is not so close as previously supposed and that it can be explained satisfactorily by indirect migratory connections *i.e.* via the southeastern Pacific on the one hand and Europe on the other.

EUROPE

All genera of the Alaskan *S. sowerbyi* Zone, except for the sparse *Pseudotoites*, are known from Europe, although *Pseudolioceras* and apparently also the poorly known *Asthenoceras* are there restricted to older beds. Of the 12 Ammonitina subgenera (incl. nominate subgen.) known from Alaska, eight were originally described from northwestern Europe [*Eudmetoceras* s.s., *E. (Euap-tetoceras)*, *Planammatoceras* (*Pseudammatoceras*), *Sonninia* (*Euhoploceras*), *Pelekodites* s.s., *P. (Spathulites)*, *Docidoceras* s.s., *D. (Trilobiticeras)*], and of the species at least two or three are in common with Europe [*Eudmetoceras klimakomphalum* (Vacek), *E. amplex-tens* (Buckman), ? *Pelekodites pelekus* (Buckman)] while five others are very closely affiliated with European species [*i.e.* to *Asthenoceras nannodes* (Buckman), *Eudmetoceras eudmetum* Buckman, *Planammatoceras benneri* (Hoffman), *Docidoceras longal-vum* (Vacek), *Hebetoxyites hebes* Buckman]. Of the other four

Alaskan subgenera two have been identified with certainty only from Wide Bay [*Docidoceras* (*Pseudocidoceras*) and *Bradfordia?* (*Pracoppelia*)]; one [*Sonninia* (*Alaskoceras*)] occurs also in south-eastern Alaska and possibly Alberta, and only one [*Pseudotoites* s.s.] is widespread around the Pacific.

The affinity to the northwestern European assemblages is close indeed; not only is the equivalence of the *E. amplexens* and *Pseudocidoceras* zonules with the *S. sowerbyi* (Standard) Zone beyond serious doubt, but some infra-zonal correlation is also suggested. This is particularly apparent in the acme-zone succession, from below, of *Eudmetoceras amplexens* (Buckman), *Sonninia* (*Euhoploceras*) *bifurcata*, n. sp., and *Witchellia sutneroides*, n. sp.; the lower two acme-zones can be correlated with the *L. discites* Subzone and the upper with the *S. trigonalis* and *W. laeviuscula* Subzones or *W. laeviuscula* Subzone. However, it appears that even in northwestern Europe the upper two subzones are distinct only in a few areas. This infra-zonal correlation is particularly surprising because the Alaskan vertical ranges for species, subgenera, and genera far exceed those in Europe (Text-fig. 8). Fortunately, as generally recognized, these range differences pertain to disappearance much more than to first appearance.

CONCLUSIONS

The *S. sowerbyi* (Standard) Zone is most commonly missing in North America; where present, the zone is usually poorly fossiliferous with the two known exceptions of Wide Bay and east-central Oregon. The ammonite fauna of the Kialagvik Formation is in all taxonomic categories related most closely to Europe and secondly only to South America. The affinities to Australo-Indonesia are less close and could be accounted for indirectly by migration via Europe and South America. All genera are also known from other continents and only *Pseudotoites*, rare in South Alaska, is restricted to the Pacific; 25% of the subgenera and 50-80% of the species appear to be restricted to North America or even to southern Alaska.

Approximately 50% of the Ammonitina genera and subgenera range higher in southern Alaska than in Europe, and the same is even true for several species. Nevertheless, the Bajocian (Standard)

zones of *S. sowerbyi*, *O. sauzei*, and *S. humphriesianum* can be identified with confidence and a subdivision of the *S. sowerbyi* Zone somewhat similar to that in Europe is suggested.

Trans-Pacific dispersion of ammonite species during the Bajocian as assumed by Arkell (1956, pp. 597-601) is not a necessary conclusion from the study of distributions, at least not for the North Pacific [*Zemistephanus* is known only from Alaska and British Columbia; *Pseudotoites* is rare in North America and there restricted to southern Alaska] and migration from Australo-Indonesia could have occurred along the continental margin or in narrow marine channels of the Gondwana continent which at this time was probably beginning to break apart (compare Irwing, 1964, figs. 10, 17; Hamilton, 1964, fig. 8).

DIVERSITY AND PALEOLATITUDE

Based on the first ammonite monograph by Imlay (1953) and on several faunal listings, Arkell (1956, p. 617) suggested, that because of high diversity the assemblages of the southern Alaska Jurassic originated at a lower latitude than their present position (57° - 62° N). High diversity has subsequently been confirmed also for the Aalenian and other Bajocian ammonite assemblages (Imlay, 1961, 1962, 1964; Westermann 1964a) and is here again demonstrated. The distribution tables of these monographs show that single ammonite assemblages contain commonly between 10 and 20 reasonably abundant species of 6 to 12 genera and three to six families. Such diversity indicates at least a temperate climate for the southern Alaska Jurassic seas; cold climate as assumed by Bain (1963, fig. 8) can certainly be refuted. Actual diversity counts are not attempted here because they are not available from other Jurassic assemblages. When compared properly with assemblages equivalent in horizontal and vertical extent, relative abundances, sample size and taxonomic "splitting," the southern Alaskan Lower Bajocian ammonite assemblages are closely comparable in diversity to their classical European equivalents. However, other larger invertebrates are scarce at Wide Bay except for abundant thin-shelled *Inoceramus* which might have been pseudoplanktonic. Typically benthonic bivalves, gastropods, and brachiopods, as well as belemnites, are extremely rare, while plant remains, particularly fragmented wooden trunk, are common at several levels.

Only a few paleomagnetic data are available from North America for the position of the Jurassic North Pole and all come from the southwestern United States; although the plots are widely scattered even for data from single formations, a mean pole position relatively displacing Alaska southward for 8-12 meridians is indicated (Collinson and Runcorn, 1960). This would shift the latitude of the southern Alaskan Jurassic from the present 57-62°N. to about 50°N., the present latitudes of northern Oregon and Vancouver Island or of southern England and Central Europe. European latitudes were, however, also appreciably lower than at present. Polar shift, possibly combined with warm east Pacific currents as at present, would fully account for temperate Jurassic seas in the area of southern Alaska. Nevertheless, the prevalence of terrigenous sediments in contrast to the abundant limestones in the European Jurassic may suggest relatively higher latitude for southern Alaska. Furthermore, low thermal gradients of the Bajocian Pacific Ocean and Atlantic "Ocean" are indicated by the extraordinary wide distributions of several ammonite species which include Europe, the southern Andes and southern Alaska. Such reduced gradient could probably be responsible for the recorded diversity without change in latitude.

FOSSIL LOCALITIES

United States Geological Survey (USGS) Mesozoic localities. (12405 collected by W. R. Smith, 1924; 19028 and 19801 by S. N. Daviess, 1944; 19862-19922 by Lewis B. Kellum, 1945; 21251 and 12252 by Ralph W. Imlay and Don J. Miller, 1948)

Field No. Catalogue No.

F-27	12405	SE. side of Wide Bay, "1.1/2 mi. from cape near islands."
44 A Km F21	19028	[Non F21 of Short Creek section] SE. side of Wide Bay, bluff 1.56 km E. of Preston Creek, about 11.0 km S. 56° W. of Hartman Isl. Massive sandstone at base of section.
44 A Km 72	19801	SE. side of Wide Bay, sea cliff c. 1.6 km E. of Preston Creek, 9.7 km S. 55° W. of Hartman Isl. Base of shaly unit below an

- unconformity, shale with limy concretions, Kialagvik Fm.
- 45 A Km F55 19862 SE. side of Wide Bay, sea cliffs 2.5 km E. of Preston Creek and 9.0 km S. 52.5° W. of Hartman Isl., elevation 7 m. Shale with sandstone stringers above massive sandstone, 43 m below top of Kialagvik Fm.
- 45 A Km F56 19863 SE. side of Wide Bay, sea cliff about 2.1 km E. of Preston Creek and 9.1 km S. 53.5° W. of Hartman Isl. (190 m SW. of USGS 19862 "where the shale dips into the sea"). Float from about 45 m below top of Kialagvik Fm., shales with stringers of sandstone.
- 45 A Km F62 19869 SE. side of Wide Bay, gully near shore line, about 2.3 km E. of Preston Creek. Interbedded dark grey blocky concretionary shale and thin stringers of grey weathering limestone, 145 m below top of Kialagvik Fm.
- 45 A Km F63 19870 Same locality as USGS 19862, but from talus at base of sea cliff. Probably from about 36 m below top of Kialagvik Fm.
- 45 A Km F112 19922 8 km SW. of West end of Wide Bay, upper Kialagvik Creek at SW. foot of Lone Hill. About 14 m below top of Kialagvik Fm.
- 45 A1 103 21251 SE. side of Wide Bay, sea cliff 8.5 km S. 46.5° W. of Hartman Island. (2.85 km E. of Preston Creek). About 150 m below top of Kialagvik Fm.
- 48 A1 104 21252 Same locality as USGS 19862. Gray siltstone, about 8 m above a massive sandstone ("probably a little lower than lot 21251").

California Academy of Science (CAS) localities

- 109 A 29011 SE. shore of Wide Bay, 5.5 km SW. of Tatcliff Island. (1.83 km E. of Preston

Creek). Black shale "just above contact of Kialagvik with Shelikof Fm."

- C.E.L. No. 68 29014 SE. side of Wide Bay, about 0.3 km W. of CAS 29011 (1.83 km E. of Preston Creek). Dark grey sandstone with basaltic dike, Kialagvik Fm.

Shell Oil Company (Shell) localities

- L 546 SE. shore of Wide Bay, about 2.2 km E. of Preston Creek, in "Mt. Frances Section." About 15 m below top of Kialagvik Fm. (for localities mentioned in text only, see Text-fig. 2).

G. E. G. Westermann (WA) localities

Field No.

- WA 1 SE. side of Wide Bay, 1.7 km E. of Preston Creek, above east end of high bluff, elevation 60 to 70 m. Subgreywacke and mudstone, some silty shale, 50-65 m stratigraphically above *E. amplexens* zonule of bluff; top of Kialagvik Fm. (Plate 2).
- WA 2 SE. side of Wide Bay, bluff 1.2 km E. of Preston Creek, elevation c.5 m. 4 m above base of 12 m interbedded shale, siltstone and greywacke below massive subgreywacke of *E. amplexens* zonule; Kialagvik Fm. (Plate 3, above, and 4).
- WA 3 SE. side of Wide Bay, subgreywacke bluff 1.6 km E. of Preston Creek. Float probably from base of bluff; *E. amplexens* zonule, Kialagvik Fm.
- WA 4 SE. side of Wide Bay, bluff 1.65 km E. of Preston Creek, 50 m W. of end of subgreywacke bluff. Mudstone, greywacke and silty shale about 15 m below top of bluff [*E. amplexens* zonule] Kialagvik Fm. (Plate 1).
- WA 5 SE. shore of Wide Bay, 1.75 km E. of Preston Creek, more westerly of the two large tectonic blocks of massive subgreywacke east of main bluffs. From talus of massive subgreywacke and some silty shale; *E. amplexens* zonule, Kialagvik Fm.
- WA 8 SE. shore of Wide Bay, 1.8 km E. of Preston Creek,

more easterly of the two large tectonic blocks of massive subgreywacke east of the main bluff with basaltic dike. *E. amplexans* zonule: about 8 m massive subgreywacke, highly fossiliferous especially at 2.2 to 0.5 m from top; underlain by 3 m mudstone and siltstone, fossiliferous especially at top and near base; overlain by several meters of crumbly shale indicating fault zone (*Pseudocidoceras* zonule missing) (Plate 3, below).

WA 10 SE. shore of Wide Bay, 2.45 to 2.55 km E. of Preston Creek (4.1 km W. of cape at end of Bay), sea cliff at both sides of little stream. 21 m dark grey shale with abundant calcareous black concretions, often in bedding planes and forming a thick "bed" at 10.5 m above base of section; highly fossiliferous throughout; *Pseudocidoceras* zonule, Kialagvik Fm. (Plate 5).

WA 11 SE shore of Wide Bay, 2.5 km E. of Preston Creek (50 m W. of WA 10). Kialagvik Fm., from base:

30 m dark grey shales with abundant calcareous concretions, especially in lower part, and thick concretionary "bed" (same as WA 10, 10.5 m) near base; *Pseudocidoceras* zonule, highly fossiliferous in lower 20 m.

15 m silty and arenaceous shale with few concretions, poorly fossiliferous.

30 m silty shale with interbedded lenticular sandstone beds, unfossiliferous.

15 m interbedded subgreywacke, sandstone and silty shale, unfossiliferous.

WA 12 SE shore of Wide Bay, 2.15 km E. of Preston Creek, elevation about 100 m, top of section beside gully adjacent to WA 13 w. 7 m thick-bedded subgreywacke (overlying c.65 m unfossiliferous shales + the Wa 15 section).

WA 13 SE. shore of Wide Bay, 2.48 km E. of Preston Creek (only 15 m W. of WA 11 but separated by fault). About 30 m shale with some concretions, fossiliferous at 3 m and 16 m from base; Kialagvik Fm.

WA 13w SE. shore of Wide Bay, 2.45 km E. of Preston Creek

- (15 m W. of WA 13). About 20 m shale with single concretions, fossiliferous near base; Kialagvik Fm.
- WA 14 SE. shore of Wide Bay, 1.95 km E. of Preston Creek, low-tide exposure about 30 m from sea cliff. Subgreywacke beds; Kialagvik Fm.
- WA 15 SE. shore of Wide Bay, 2.15 km E. of Preston Creek. 20-30 m shales with some concretions, partly slumped and faulted; at 3 to 16 m from base moderately fossiliferous except for abundant *Inoceramus*; Kialagvik Fm.

SYSTEMATIC DESCRIPTION

REPOSITORY OF TYPES

Specimens collected by the U.S. Geological Survey, which become types by description or figuring, are deposited in the U.S. National Museum (USNM), Washington, D.C.; specimens collected by the author are deposited in the Department of Geology at McMaster University (McM.), Hamilton, Ontario, under the catalogue numbers J Some fossils are now being returned from the U.S. Geological Survey to the California Academy of Sciences (CAS) in San Francisco, California.

MEASUREMENTS OF AMMONOIDS

The measurements taken and their abbreviations are the same as in the first part of this monograph (Westermann, 1964a, p. 357).

Family **PHYLLOCERATIDAE** Zittel, 1884

Subfamily **PHYLLOCERATINAE** Zittel, 1884

Genus **PHYLLOCERAS** Suess, 1865

Subgenus **ZETOCERAS** Kovacs, 1939

Phylloceras (Zetoceras) cf. **P. zetes** (d'Orbigny), 1850

Pl. 8, fig. 4; Text-fig. 11

Material. — A single fragmentary phragmocone with test remains came from the *Pseudocidoceras* zonule, *S. sowerbyi* Zone, of WA 10 at 15 m (J1018).

The specimen closely resembles the phragmocone with crushed umbilicus recently described by Imlay (1964, p. B31, pl. 2, figs. 3,4) under *Phylloceras* cf. *P. kunthi* Neumayr from the *O. sauzei* Zone of the Tuxedni Formation in the Talkeetna Mountains,

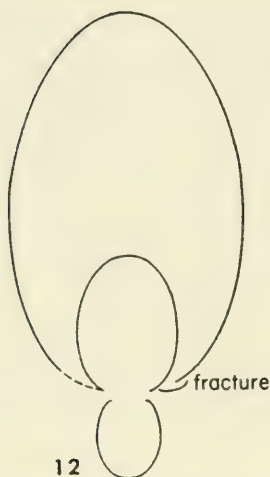


11

Text-fig. 11. — Cross-section of *Phylloceras* (*Zetoceras*) cf. *P. zetes* (d'Orb.), phragmocone fragment, loc. WA 15 in the *Pseudocidoceras* zonule (McM J 1018); $\times 1$.

Alaska. Imlay's specimen also has similar irregularly tetraphyllic saddles (from plastotype). *P. zetes* has recently been reinvestigated by Géczy (1967, p. 9) who concluded that in Hungary *Zetoceras* cannot be separated from *Phylloceras*. *Zetoceras* is, therefore, placed as a subgenus in *Phylloceras*.

The compressed whorl section with weakly convex, converging flanks, narrowly rounded venter, umbilical margin and overhanging umbilical wall, as well as the rectiradiate lirae and the septal suture match Géczy's specimen from the Pliensbachian of Hungary. From Prince Patric Island in the Canadian Arctic, Frebold (1961, p. 5, pls. 7, 8, 9, fig. 2) described the dubious new species *P. (Zetoceras) thorsteinssoni* which was based on a single totally septate internal mold and an undescribed fragment, the only certain difference from *P. zetes* admittedly being its younger age; possible distinctions of the "new species" include a shallow umbilical slope and missing radial folds. The Arctic specimens came from the *Arkelloceras* beds of the Wilkie Point Formation which probably correspond to the *O. sauzei* Zone, a date based on the occurrence of *Arkelloceras* in the *O. sauzei* Zone of the Alberta foothills (Westermann, 1964b) and Wide Bay (Imlay, 1964, p. B53, pl. 28, figs. 7-9; generic identity here verified).



Text-fig. 12. — Cross-section of *Partschiceras ellipticum*, n. sp., incomplete phragmocone, loc. WA 8 in the *E. amplexans* zonule (McM J 962); $\times 1$.

Genus **PARTSCHICERAS** Fucini, 1923

Partschiceras ellipticum Westermann, n. sp. Pl. 8, figs. 1,2; Text fig. 12

(?) 1964. *Macrophylloceras* sp. indet. A, Imlay (SE Alaska), U.S. Geol. Sur., Prof. Pap. 418-B, p. B31, pl. 1, figs. 1-7.

1964. *Partschiceras gardanum* (Vacek), 1886, subsp.?, Westermann. (Wide Bay I) Bull. Amer. Paleont., vol. 47, No. 216, p. 453, pl. 76.

(?) 1964. *Partschiceras* cf. *P. gardanum* (Vacek), 1886, Westermann, *id.*, p. 447, pl. 74, figs. 1-3.

Holotype. — Westermann, 1964a, p. 453, pl. 76; well-preserved large phragmocone, largely with test, septal suture and inner whorls exposed. Repository: Cal. Acad. Sci. (San Francisco) 12606.

Locus typicus. — Cal. Acad. Sci. 29017 (field No. 99): "Cliff exposure on the west shore of the south end of Wide Bay, inside hook made by long sand spit."

Stratum typicum. — Kialagvik Formation, upper *E. howelli* Zone.

Derivatio nominis. — With regard to the elliptical whorl section.

Diagnosis. — An obvolute species of *Partschiceras* with compressed elliptical whorl section and simple weak costae.

Probable distribution and age. — *E. howelli* Zone to *S. humphriesianum* Zone of southern Alaska (Wide Bay, Cook Inlet, and Talkeetna Mountains).

Material from the S. sowerbyi Zone.— One incomplete phragmocone from WA 10 at 2.5 m (J 1013); one phragmocone fragment from scree of WA 10 (J 1916); one incomplete phragmocone from WA 8, lower part (J 962). All internal molds with test remains, *E. amplexans* and lower *Pseudocidoceras* zonules of Kialagvik Formation, Wide Bay.

Description.— The whorls are extremely involute to obvolute and compressed-elliptical in section; the flanks are evenly convex sloping to the occluded umbilicus and to the narrowly curved, somewhat arched venter.

The inner whorls bear slightly prosoradiate² lirae. At about 50 mm diameter, blunt and weak, rectiradiate plications arise on the outer one-half to two-thirds of the whorl; subsequently, these simple costae strengthen somewhat, often becoming slightly prosoradiate, and cross more or less straight over the venter where they reach their greatest relative strength.

The septal suture has a graded series of slender, essentially diphyllic saddles.

Comparison.— The holotype from the *E. howelli* Zone and the specimens from the *S. sowerbyi* Zone of Wide Bay match the "*Macrophylloceras* sp. indet. A" of Imlay (1964, p. B31) from the *O. sauzei* and *S. humphriesianum* Zones of southeastern Alaska. However, possibly because of imperfect preservation, the "vague flexuous undulations" on the innermost whorls of the Cook Inlet species (*loc. cit.*) cannot be seen on the Wide Bay specimens.

This species appears closely related to *Partschiceras grossicostatum* (Imlay, 1953, p. 74, pl. 25) from the Callovian of southeastern Alaska which is distinguished in the extremely dense secondary costation, especially on the venter where the primary costae become obsolete. Significantly, a specimen morphologically exactly intermediate between the Lower Bajocian and Callovian Alaskan species has been described by Imlay (1962, p. A5) from the early Upper Bajocian *Magasphaeroceras rotundum* assemblage of the Tuxedni Formation, Cook Inlet; while coiling and whorl section are the same as in *P. ellipticum* and *P. grossicostatum*, the costation is intermediate consisting of continuous primaries and

² Correct spelling for "prorsiradiate" *auct.*, according to Classics Dept., McMaster University.

relatively strong short secondaries singly intercalated on the venter.

All other *Partschiceras* species (including the synonym *Macrophylloceras* Spath, 1927) are distinguished by the subrectangular to subsquare whorl section and stronger costation or stronger costation. Some resemblance can be seen to *P. gardanum* (Vacek, 1886, p. 70, pl. 6, figs. 1-3) from the partly condensed Aalenian to basal Bajocian beds of Cap S. Vigilio in the Alps which is distinguished by the development of an umbilical edge.

The Alaska species agrees in the whorl shape and coiling with *Phylloceras heterophyllum* (J. Sowerby), type species of *Phylloceras*.

Measurements. —	Dmm	W%	H%
holotype (phragm.).	92	38	57
“	51	41	65
J 962 (phragm.)	c.78	—	c.62
“	34	43	59
J 1013 (phragm.)	68	39	60

Subfamily **CALLIPHYLLOCERATINAE** Spath, 1927

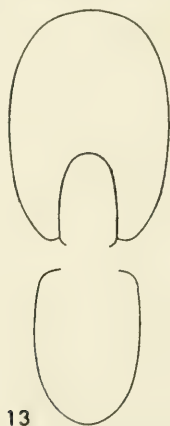
Genus **HOLCOPHYLLOCERAS** Spath, 1927

Holcophylloceras costisparsum Imlay, 1964

Pl. 8, figs. 3a, b; Pl. 9, figs. 1a, b; Text-fig. 13

1962. *Calliphylloceras* sp., Imlay (SE Alaska), U.S. Geol. Sur., Prof. Pap. 418-A, p. A5, pl. 1, fig. 8.

1964. *Holcophylloceras costisparsum* Imlay, n. sp., Imlay (SE Alaska), U.S. Geol. Sur., Prof. Pap. 418-B, p. B32, pl. 1, figs. 1-12, 14-17.



Text-fig. 13. — Cross-section of *Holcophylloceras costisparsum* Imlay, incomplete phragmocone, loc. USGS 19862 in the *Pseudocidoceras* zonule (USGS 160921); $\times$ 1.

Material. — One internal mold of a damaged phragmocone and one incomplete body chamber from USGS 21252; one well-preserved incomplete phragmocone with exposed inner whorls and one fragment, from USGS 19862 (USNM 160921); one incomplete body chamber with shell remains from scree of WA 5 (J 1012); (?) one crushed fragment from WA 10 at 22 m (J 1008); one internal mold of a phragmocone fragment with incomplete body chamber, ? one juvenile or nucleus from scree of WA 13 w (J 1011). From the *Pseudocidoceras* and *E. amplexens* zonules of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The whorls are strongly involute to obvolute with moderately compressed elliptical, often somewhat ovate section becoming more or less strongly subrectangular towards the end of the phragmocone. There are five to seven sigmoid constrictions per whorl, distally only slightly projecting, sometimes rectiradiate and usually crossing the venter with slight convexity or very obtuse arch. The internal mold is almost smooth except for some barely visible, somewhat falcoid plications on the body chamber which become irregular and obscure on the middle and inner flank. The septal suture has a graded sequence of slender diphylic saddles.

Discussion. — There is perfect resemblance with *H. costisparsum* Imlay from the *O. sauzei*, *S. humphriesianum*, and *S. subfurcatum* Zones of the Cook Inlet region, southeastern Alaska, extending the range of this species throughout most of the Bajocian (*s.s.*). There can be little doubt that the early Upper Bajocian “*Calliphyloceras* sp.” of Imlay (1962, p. A5, pl. 1, fig. 8) is identical with *H. costisparsum* in which the constrictions are also at least in part restricted to the internal mold (*cf.* Imlay, 1964, pl. 1, fig. 15) indicating the insignificance of this feature for the distinction of *Calliphyloceras* from *Holcophylloceras*.

Holcophylloceras cf. H. ultramontanum (Zittel) from the subadjacent *E. howelli* Zone of Wide Bay (Westermann, 1964a, p. 448, pl. 74, figs. 4-7) is distinguished only by the falcoid and strongly projected constrictions which on the externside are strongly convex or arched comprising almost a right angle.

H. costisparsum is morphologically and stratigraphically intermediate between *H. ultramontanum* (Zittel, 1869, p. 66, pl. 1, figs.

4-6), ranging throughout the Aalenian (+? *S. sowerbyi* Zone), and *H. mediterraneum* (Neumayr, 1871, p. 340, pl. 17, figs. 2-5) [= *H. zignodianum* d'Orbigny, 1848, pl. 182] which ranges from the Upper Bajocian to the Tithonian (Wendt, 1963, p. 115). *H. ultramontanum* is distinguished by fewer constrictions of falcoid shape, or bearing lateral "tongues," and by more compressed whorls; *H. mediterraneum* has a larger umbilicus and stronger costation. In *A. costisparsum* the constrictions are essentially restricted to the internal mold thus resembling *Calliphyllloceras*. Another intermediary is the dubious *H. deslongchampsii* (Brasil, 1895, p. 29, pl. 1, figs. 6-8), known only in a few inner whorls from the *S. humphriesianum* Zone of Sully in Normandy, which, reversely appears to resemble *H. ultramontanum* in whorl shape and coiling, but *H. mediterraneum* in the constrictions. The taxonomic significance of the shallow linguulate depressions projecting mid-laterally from the constrictions is doubtful since they have been observed seemingly irregularly in a number of species (cf. d'Orbigny, 1848, pl. 182, fig. 3).

Measurements. —

	Dmm	W%	H%	U%
USNM 160921 (phragm.)	(c.70)	—	—	—
" "	55	40	56.5	6.5
" "	35	38.5	54	c.7

Family **LYTOCERATIDAE** Neumayr, 1875

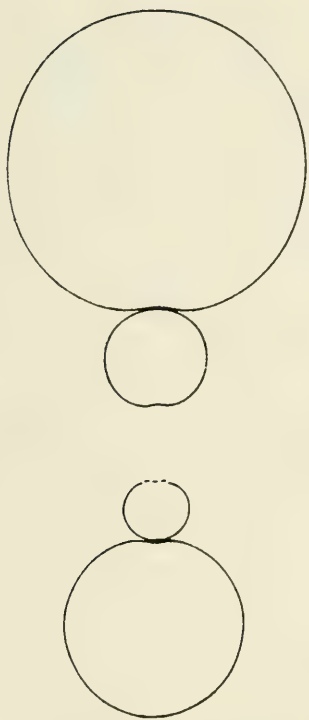
Subfamily **LYTOCERATINAE** Neumayr, 1875

Genus **LYTOCERAS** Suess, 1865

Lytoceras sp. aff. **L. eudesianum** (d'Orbigny), 1846

Pl. 9, figs. 2,3; Text-fig. 14

Material. — Single phragmocone fragments from USGS 19862 and 21251; one small phragmocone from WA 10, basal 2 m (J 1010); one large incomplete phragmocone with test remains and one fragmentary phragmocone from WA 10 at 14-16 m (J 1005); one incomplete phragmocone with test remains (J 1004) and one fragment (J 1014) from WA 11 at 16-18 m; one phragmocone fragment with test remains from WA 13 at 13-16 m (J 1009). All internal molds, except where indicated, from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.



Text-fig. 14. — Cross-section of *Lyto-*
ceras sp. aff. *L. eudesianum* (d'Orb.), in-
complete phragmocone, loc. WA 10 in the
Pseudocidoceras zonule (McM J 1005);
× 1.

The shell is planulate with advolute circular whorls. The internal mold is usually smooth, except for markings of "rhythmic" growth on a single small phragmocone (J 1010). The test bears rectiradiate sometimes slightly flexed lirae or riblets of somewhat uneven strength, every third or fourth of which is finely crinkled (festooned) at least on the outer whorls. The septal suture has relatively simple and regular saddle endings.

This species matches D'Orbigny's figure of the holotype (1846, pl. 128) except for the missing lamellar flares. Because of the much finer crenulation, it is unlikely that the intermittent and somewhat raised crinkled lirae or riblets are the remnants of dissolved flares. *L. neumayri* Pugin (1964, p. 34, pl. 2, figs. 2-3) is distinguished by smooth lirae or riblets and the absence of flares. *L. espinazitum* Pugin (1964, p. 32; for "*L. eudesianum*" of Gottsche, 1878, p. 8, pl. 1, fig. 1) is distinguished by regular constrictions. However,

Imlay (1964, p. B32) who recently described but did not figure the first probable *L. eudesianum* from the *O. sauzei* Zone of south-eastern Alaska, mentioned "weak constrictions." *Lytoceras eudesianum* has previously been known to range from the *S. humphriesianum* Zone to the Lower Callovian of Europe only (Pugin, 1964, p. 32; Sturani, 1964b, p. 12; Wendt, 1964, p. 116). While Lower Jurassic *Lytoceras* species persist into the Aalenian where they become increasingly rare, the genus is almost unknown from the Lower Bajocian *S. sowerbyi* and *O. sauzei* Zones. Besides the rare *L. espinazitum* mentioned above, there is *L. subfrancisci* Sturani (1964b, p. 13; synonym "*L. vaceki*" Géczy, 1964 = *L. francisci* Vacek, 1886, pl. 2, *non* Oppel) with a range from the Aalenian to the *S. humphriesianum* Zone, which is distinguished by the compressed elliptical whorls (and spiralic lirae) and said to be intermediate between the Toarcian *L. francisci* and *L. eudesianum*. *S. subfrancisci* has intermittent crinkled riblets or lirae on the inner whorls and lirae with intermittent blunt riblets on the outer whorls, without flares. The Alaskan species is, therefore, morphologically intermediate between *L. subfrancisci* Sturani and *L. eudesianum* (d'Orb.).

Measurements. —

	Dmm	W%	H%	U%
J1005 (phragm.)	94	41.5	42	33
"	31	43.5	41.5	34
J1010 (phragm.)	50	38	40	37

Family **STRIGOCERATIDAE** Buckman, 1924

Genus **HEBETOXYITES** Buckman, 1924

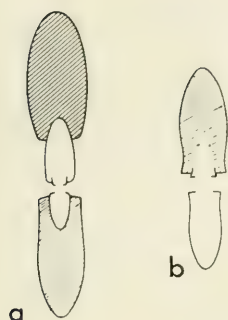
Type species by original designation is *H. hebes* Buckman from the upper *S. sowerbyi* Zone of Dundry in Somerset. The genus is distinguished from contemporary *Strigoceras* by the absence of a keel and possibly also by a slightly less complex septal suture.

To the author's knowledge, no microconchs with lateral lappets have hitherto been described from this family.

Hebetoxyites sp. aff. **H. hebes** Buckman, 1924 [♂]

Pl. 10, figs. 1, 2; Text-figs. 15 a-b

Material. — Two small but adult internal molds with test remains, one with complete body chamber and lappet bearing aper-



Text-fig. 15a-b. — Cross-sections of *Hebetoxyites* sp. aff. *H. hebes* Buckman, microconchs from the *E. amplexens* zonule; $\times 1$. a. Complete specimen with lappet, loc. WA 5 (McM J 1043). b. Incomplete specimen, loc. WA 8 (McM J 1041).

ture, and a few poorly preserved fragments including body chamber imprint with lappet, from the upper part of WA 8 and scree of WA 5. All from the *E. amplexens* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The phragmocone is typically oxycone with involute compressed whorls, converging outer flanks and narrowly rounded venter. The inner flanks are parallel up to the sharp umbilical margin on the complete specimen (J 1043), but markedly convex beside the raised umbilical edge at the other specimen (J 1041), causing a slight rise of the flanks at about two-fifths whorl height. The phragmocone measures only 20-30 mm in diameter. The body chamber, only about three-fifths whorls long, becomes inflated and assumes "elliptical" coiling, with the umbilical seam egressing almost radially and finally returning to spiral coiling; whorl height is reduced while the venter becomes more broadly rounded. The aperture has a slightly projected broad ventral lip and prominent mid-lateral lappets with thickened test. Both preserved lappets (left lappet of J 1043 and right imprint from same) are incomplete consisting of narrow tongue-like projections. The complete shell diameter varies between approximately 30 and 45 mm.

The costation is obsolete on the complete specimen (J 1043) except for faint rursiradiate plication visible under oblique illumination on the outer flanks of the body chamber. The somewhat smaller incomplete specimen (J 1041) bears, on the whole ultimate whorl somewhat falcoid rursiradiate blunt costae or plications

which become obsolete on the mid-lateral spiral rise. The inner convex part of the flank is smooth. The plications die out gradually beside the venter.

The septal suture is only moderately complex, even considering the small size. E is well developed and as deep as L, the E/L and L/U saddles are of similar size; these umbilical elements form a graded series with rectiradiate "saddle line".

Discussion. — While this is the first description of *Hebetoxyites* from the Americas, supposed *H. cf. hebes* and *H. cf. clypeus* Buckman have been recorded by Lupton (1941) from the upper *S. sowerbyi* or *O. sauzei* Zone of east-central Oregon.

The whorl shape and coiling of the phragmocone and the septal suture are good evidence that this is a strigoceratid closely affiliated with *Hebetoxyites*. A literature survey indicates that specimens with complete body chambers are exceedingly rare in the Strigoceratidae. The fact that small specimens with incomplete body chambers which may include microconchs as well as immatures, have rarely been figured, may be due to the difficulty of identifying small strigoceratids since many of the diagnostic features are developed only in the adult macroconchiate phragmocone or microconchiate body chamber. The body chamber of these microconchs, measuring barely one-half the size of figured macroconchs, deviates from the described macroconchiate strigoceratids in the egression of the umbilical seam, *i.e.* "elliptical coiling". This is a well-known and common microconchiate feature in other families. Nevertheless, affinity of the Wide Bay microconchiate phragmocones is close to the macroconchiate *H. hebes* Buckman. Consequently, the author does not hesitate to place these specimens in *Hebetoxyites* and, furthermore, sees no necessity to create a new "monosexual" subgenus for these probable male shells.

There is also some resemblance to the larger umbilicate and less discoidal *Bradfordia*; this is considered of phylogenetic significance suggesting common ancestors.

Measurements. —

	Dmm	W%	H%	U%
J1043 (apert.)	43	19	40	21
(phragm.)	29	20	52	6
J1041 (phragm.)	26	23	52	8.5

Family **OPPELIIDAE** Bonarelli, 1894Subfamily **OPPELIINAE** Bonarelli, 1894

Bradfordia and *Oppelia*. — The genus *Oppelia* Waagen, 1869 [type species *Ammonites subradiatus* J. de C. Sowerby; holotype refigured in Arkell, 1951, p. 51] was defined in the Treatise (Arkell, *et al.*, 1957, p. L 275) as “compressed, involute, feebly keeled; with distant falcoid primary ribbing and close fine secondaries on ventrolateral edge”. In contrast, *Bradfordia* Buckman, 1910 [type species *B. liomphala* Buckman, 1910] was defined (*loc. cit.*) as comprising the “group of *Oppelia praeradiata* H. Douvillé; moderately involute to involute, unkeeled, venter rounded, smooth, umbilical wall steep, umbilical edge sharp or raised; outer half of whorl sides with fine, somewhat rursiradiate ribbing which is not projected on shoulders. Sutures simple for the family”. The alleged occurrence of *Bradfordia* in Argentina was based on the erroneous identification of *Eudmetoceras* (*Euaptetoceras*) *klimakomphalum moericki* (Jaworski, 1926). However, as most recently pointed out by Géczy (1967, p. 224) *Bradfordia* is difficult to define and the Treatise diagnosis as quoted above is unsatisfactory especially with regard to the costation. In contrast to the Treatise, the original author (Buckman, 1910, p. 95) excluded *O. praeradiata* from the genus because of the slightly projected and truncated costae. Furthermore, only a year prior to the Treatise, Arkell (1956, p. 166) placed in *Bradfordia* three species with strongly projected costae, *i.e.* ‘*Oppelia*’ *gracililobata* Vacek, ‘*O.*’ *subplicatella* Vacek, and ‘*Harpoceras*’ *blumius* de Gregorio [syn. *O. platyomphala* Vacek]. The first two species differ also in the differentiation of the costae which closely resemble those of *Oppelia s. s.* The raised umbilical edge of these species is not a diagnostic feature for *Bradfordia*, because it is missing in the type species.

The septal suture of *Bradfordia* is less complex, with smaller E, broader L, and fewer umbilical elements than in *Oppelia*. However, the dubious “*Amblyoxyites*” Buckman, 1922, which closely resembles involute *Bradfordia* and is usually placed in tentative synonymy, has the suture of *Oppelia*.

The Mediterranean ‘*O.*’ *gracililobata*, ‘*O.*’ *subplicatella* and even more so the Alaskan *B.?* *oppeliiformis*, n. sp., combine fea-

tures of *Bradfordia* with those of *Oppelia*; the sole distinction of the Wide Bay species from *Oppelia s. s.* is in the narrowly rounded venter and probably also in the septal suture which actually appears intermediate between *Bradfordia* and *Oppelia*. According to the number of characters-in-common this species group should probably be classified with *Oppelia*, but the application of the conventional positive weighing of ventral features would place it in *Bradfordia*. This species group is, therefore, classified as new subgenus *Praeoppelia* and tentatively placed in *Bradfordia*.

Genus **BRADFORDIA** Buckman, 1910

Subgenus **BRADFORDIA ? (PRAEOPELIA)** Westermann, n. subgen.

Type species. — *B.?* (*P.*) *oppeliiformis*, n. sp.

Subgenus diagnosis. — Large, strongly compressed, involute, venter rounded; with distant falcoid primaries and short dense projected secondaries fading out ventrally or forming blunt chevrons; resembling *Oppelia s. s.* except for the venter (and the less developed septal suture).

Remarks. — The subgenus probably includes '*O.*' *gracililobata* Vacek of which the inner whorls are poorly known [the inner whorls figured by Vacek, 1886, pl. 10, figs. 2, 3, are not conspecific; *fide* Géczy, 1967, p. 225] and "*O.*" *subplicatella* Vacek, a possible synonym. However, both appear to differ in the septal suture with less developed E lobes and E/L saddles. All are from the (lower) *S. sowerbyi* Zone.

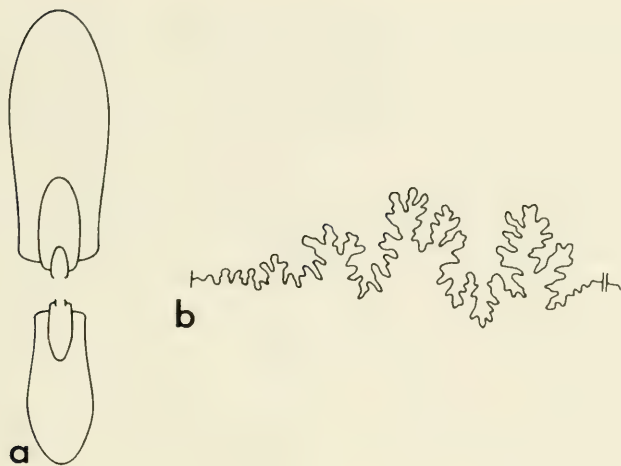
Bradfordia? (Praeoppelia) oppeliiformis Westermann, n. sp.

Pl. 10, figs. 3-6; Pls. 11, 12; Text-figs. 16a-b

Holotype. — Pl. 10, fig. 6; Pl. 20; well-preserved complete phragmocone with incomplete crushed body chamber. Repository: USNM 160922.

Locus typicus. — U.S. Geological Survey Mesozoic locality 19863 [= 45 AKm F56 (float), coll. L. B. Kellum, 1945], sea cliff on the southeastern side of Wide Bay.

Stratum typicum. — Shales of the upper Kialagvik Formation, probably in or subjacent to the basal *Pseudocidoceras* zonule, *S. sowerbyi* Zone; associated with *Eudmetoceras klimakomphalum discoidale*, n. subsp., and *Docidoceras camachoi*, n. sp.



Text-fig. 16 a-b—*Bradfordia?* (*Pracoppelia*) *oppeliiformis*, n. sp. a. Cross-section of phragmocone, loc. USGS 21252 in the *Pseudocidoceras* zonule (USNM 160923); $\times 1$. b. External septal suture, loc. UW WA-11, lot 37 (UW 13180); $\times 1.5$.

Derivatio nominis.—Reflecting the close affinity to *Oppelia* s.s.

Age.—(Lower) *S. sowerbyi* Zone.

Diagnosis.—A species of *D.?* (*Pracoppelia*) with strongly compressed inner whorls, outer whorls compressed subelliptical with inner flanks sloping gently towards the somewhat rounded not markedly raised umbilical margin.

Material.—The holotype and three somewhat crushed incomplete internal molds from USGS 19863; one partly crushed internal mold from USGS 19862; one large phragmocone and one crushed juvenile or inner whorl from CAS 29011; one well-preserved phragmocone with preserved nucleus and test from USGS 21252 (USNM 160923); one large phragmocone with well-preserved septal suture from UW WA-111, lot 37 (UW 13180); one slightly crushed phragmocone, internal mold, from WA 15 at 3 m (J 1039); one incomplete phragmocone with preserved nucleus from scree of WA 5 (J 1040). All from the upper Kialagvik Formation, probably

E. amplexans to basal *Pseudocidoceras* zonules of the lower *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description.—The nucleus at 12-15 mm diameter consists of smooth, moderately involute, strongly compressed elliptical whorls with shallow umbilicus, the convex sides sloping gently to the umbilical seam. Subsequently, a narrow umbilical wall with somewhat rounded margin develops, the whorls become involute, the inner flanks flatten but continue to slope toward the umbilicus so that the greatest whorl width is retained mid-laterally, and the typical costation develops. The immature costation consists of blunt somewhat irregular falcate primaries which are mainly superficial but become stronger on the outer one-third of the flank, and of short blunt strongly prosocline secondaries on the rounded shoulders which are singly and in pairs intercalated and cross weakly over the venter.

The mature phragmocone retains the strongly compressed involute whorls with convex flanks. However, the umbilicus deepens somewhat, due to the slightly raised rounded umbilical margin and the corresponding development of a shallow depression on the lowermost flanks; the whorls remain thickest at or just above the middle of the flanks. The outer flanks converge gently, often markedly flattened, towards the evenly and narrowly rounded venter which may widen somewhat towards the end of the phragmocone. The mature costation consists of somewhat irregular, more or less strongly concave (distally projected) primaries on the outer half of the flank, a few of them continuing faintly onto the inner flanks forming weakly falcate to falcoid costae, and of numerous prosoradiate short secondaries on the shoulders which become medially obsolete or cross the venter convexly curved or arcuate. The primaries are sometimes obscurely bundled in pairs at about two-thirds whorl height, and the secondaries are born about as often by anastomosis, bifurcation of primaries or intercalation. At the end of large phragmocones, both primaries and secondaries weaken if the latter do not become obsolete.

The complete phragmocone measures approximately 120 mm in diameter. The body chamber is known only from the holotype where it is incomplete (one-half whorl). The full diameter is esti-

mated at 160 mm. The umbilicus remains narrow and shallow with the umbilical wall rounding into the whorl sides; the externside is broadly rounded. The body chamber is almost smooth except for somewhat irregular more or less rectiradiate plications on the outer flanks.

The septal suture is moderately complex (Text-fig. 166). E is large and only slightly shorter than L; L is broad and trifold with short thick stems; the L/U saddle is at least as wide and high as E/L; the umbilical lobes terminate at a common radius with L; U_2 is about half as broad as L and the broad U_2/U_3 saddle about two-thirds as large as L/ U_2 (2d and 3d morph. lat.); the other umbilical elements are much smaller with only the outer saddle fully developed bearing first and second-order frilling. The suture is, therefore, intermediate in character between *Bradfordia* (s. s.) and *Oppelia* with respect to the size of E and the number of major umbilical elements.

Discussion.—This new species is most closely related to ‘*Oppelia*’ *subplicatella* and ‘*O.*’ *gracililobata*, Vacek spp., of the Mediterranean lower *S. sowerbyi* Zone, but distinguished by the more involute and compressed inner whorls, the depressed and less developed circum-umbilical area and, probably, the larger E lobe.

There are also some striking resemblances to the internal molds (without the hollow-floored keel) of *Eudmetoceras* (*Euaetetoceras*) *amplectens* (Buckman) and to a lesser degree also to *E. (E.) klimakomphalum discoideale*, n. subsp., both of which are associated.

The phylogenetic origin of the Oppeliidae arising with *Bradfordia* from *Eudmetoceras* has repeatedly been suggested (Arkell *et al.*, 1957, p. L 275; Géczy, 1967, p. 225) and the Alaskan evidence favours this hypothesis if *Praeoppelia* is included in *Bradfordia*. Of special interest is the regional morphological “habitus” of the evolving lineages giving rise to the vexing problem of possible polyphyly or ecotypes: the Alaskan *E. amplectens*, *E. klimakomphalum*, and *B? oppeliiformis* are all distinguished from their Mediterranean counterparts in the umbilicus which has a less developed umbilical margin or edge. The same “habitus” is also present in northwest Europe and the southern Andes, so that *E. amplectens* appears here

closer to the Oppeliidae ancestry than *E. klimakomphalum* while this is reversed in the Mediterranean (Géczy, *loc. cit.*).

Significantly, this very early oppeliid resembles the type species of *Oppelia* altogether more closely than typical *Bradfordia*. *B.?* *oppeliiformis* is distinguished from the type species *Oppelia subradiata* only in the narrowly rounded venter and the less complex umbilical lobes.

Measurements. —

	Dmm	W%	H%	U%	P	S
holotype (body ch.)	c.160	—	—	—	—	—
(phragm.)	108	20	54.5	9.3	30-35	obsol.
"	71	20	55	11	—	—
"	47	19	54	13	30	55-60
USNM 160923 (phragm.)	65	22	55	9.2	25-30	c.55
"	25	22	50	19	(20-25)	c.45

Family **HILDOCERATIDAE** Hyatt, 1867

Subfamily **HARPOCERATINAE** Neumayr, 1875

Genus **PSEUDOLIOCERAS** Buckman, 1889

Type species. — *Ammonites compactilis* Simpson in Buckman, 1889.

Pseudolioceras maclintocki (Haughton) 1858, emend.³

1858. *Ammonites m'clintocki* Haughton (Canadian Arctic), Roy. Dublin Soc., Jour., p. 244, pl. 9, figs. 2-4.

1957b. *Ludwigia m'clintocki* (Haughton), Frebold (Canadian Arctic), Geol. Sur. Canada, Bull. 41, p. 7, pl. 5, figs. 3, 4.

1960. *Pseudolioceras m'clintocki* (Haughton), Frebold (Canadian Arctic), Geol. Sur. Canada, Bull. 59, p. 20, pls. 8-13 (?).

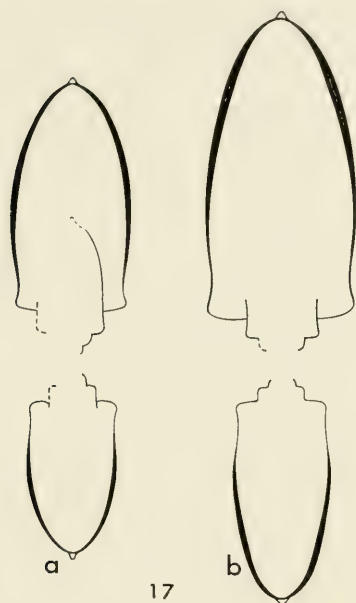
This species has been discussed in the first part of this monograph (Westermann, 1964a, p. 422) in which *P. maclintocki whiteavesi* (White) was redescribed from the *E. howelli* Zone.

Pseudolioceras maclintocki fastigatum Westermann, n. subsp.

Pl. 13, figs. 1, 2; Text-figs. 17a-b

Holotype. — Pl. 13, figs. 1a, b; Text-fig. 17a; well-preserved in-

³According to the 1961 Code of Zoological Nomenclature, no apostrophes are to be used (Article 27); the earlier Copenhagen decision to change the spelling of *m'-* or *mc-* to *mac-* was retained as a recommendation in the 1961 Code.



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Text-fig. 17 a-b.—*Pseudolioceras macklintocki fastigatum*, n. subsp.; $\times 1$.
a. Holotype, cross-section through complete phragmocone. b. Almost complete phragmocone, loc. CAS 29011 (CAS 13110).

ternal mold with some test remains, of complete phragmocone with beginning of body chamber. Repository: USNM 160924.

Locus typicus.—U.S. Geol. Survey Mesozoic locality 21252, sea cliff on SE side of Wide Bay, Alaska Peninsula.

Stratum typicum.—Upper Kialagvik Formation; probably *Pseudocidoceras* zonule, 8 m above base.

Derivatio nominis.—With regard to the whorl section which tends to develop a fastigate venter.

Age.—*S. sowerbyi* Zone, probably lower part.

Diagnosis.—A subspecies of *P. macklintocki* with umbilical ridge, strongly converging outer flanks, venter tending to be fastigate, and costae becoming obsolete on the inner flank.

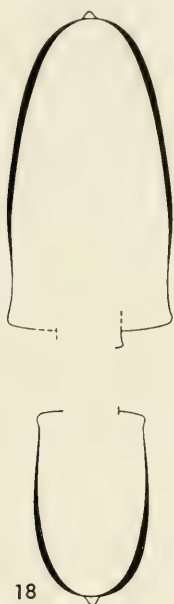
Material.—Four incomplete and partially crushed specimens from USGS 12405; one incomplete body chamber with crushed phragmocone from USGS 19801; one phragmocone and several

fragments from USGS 19862; holotype from USGS 21252; one almost complete phragmocone, only slightly damaged and one crushed specimen from CAS 29011; one partially crushed inner whorl with remains of deformed phragmocone from WA 10 at 0.1 m; three moderately preserved inner whorls with fragments of body chambers from WA 15 at 3 m; one small specimen probably with part of body chamber from WA 15 at 9 m; one large phragmocone from UW-WA 111, lot 37. All are internal molds mostly with test remains, from the lower part of the shales (including lower *Pseudocidoceras* zonule) overlying the *E. amplexens* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Remarks.—No complete description needs to be given here because the subspecies resembles closely *P. maclintocki whiteavesi* (White) described in the first part of this monograph. The moderately involute coiling and the adolescent development of a typical umbilical margin are the same. However, the whorl section is usually markedly distinct in the outer flanks which converge more strongly and in the venter which is more narrowly rounded beneath the keel or frequently almost fastigate, at least in the internal mold. Furthermore, the falcate ribs usually fade on the inner flank so that the umbilical ridge and the shallow lower-lateral groove tend to become smooth on the last phragmocone whorl, while the concave outer part of the ribs is at least as broad but blunter than in *P. maclintocki whiteavesi*. These minor differences are marked on the last two or three whorls of the phragmocone of average size while the end of large phragmocones and the body chamber may not be significantly different.

There appears to be some morphological overlap between the two Wide Bay subspecies. However, the sample of this new subspecies is insufficient for statistical analysis and quantification of the respective features is difficult. Nevertheless, some significant morphological change has certainly taken place around the Aalenian-Bajocian boundary indicating a new chrono-subspecies.

The vertical range of *P. maclintocki* (Haughton), including the three successive subspecies *P. maclintocki s.s.*, *P. m. whiteavesi* (White) and *P. m. fastigiatum* is now known to extend throughout the Aalenian and into the *S. sowerbyi* Zone of the Bajocian, a time



Text-fig. 18. — Cross-section of *Pseudolioceras maclintocki whiteavesi* (White), lectotype, *E. howelli* Zone of "Wrangel Bay"; shown for comparison; $\times 1$.

interval equivalent to the range of the whole genus (in the Toarcian) in Europe.

Because of the converging outer flanks and the reduction of the costae stems, this subspecies resembles typical Toarcian *Pseudolioceras*, such as *P. compactile* (Simpson) and *P. lythense* (Young and Bird), more closely than its ancestral subspecies. The evolution of *P. maclintocki fastigatum* may therefore be called "retrogressive".

Measurements. —

	Dmm	W%	H%	U%	P-S
holotype (end phragm.)	69	23.5	48	16.5	18

***Pseudolioceras costistriatum* Westermann, n. sp.**

Pl. 13, figs. 3-6; Text-figs. 19, 20

Holotype. — Pl. 6, figs. 3a,b; Text-fig. 19; Internal mold of in-



Text-fig. 19.—Cross-section of *Pseudolionoceras costistriatum*, n. sp., holotype, incomplete body chamber with damaged phragmocone; $\times 1$.

complete body chamber with damaged phragmocone. Repository: McM. J 1056.

Locus typicus.—Locality WA 11 at 30 m, sea cliff at S.E. shore of Wide Bay, Alaskan Peninsula.

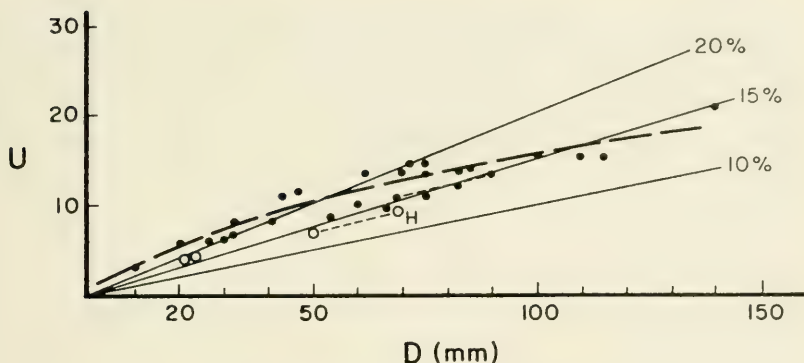
Stratum typicum.—Upper *Pseudodionoceras* zonule (19.5 m above concretions bed), upper Kialagvik Formation.

Age.—*S. sowerbyi* Zone, Bajocian.

Material.—The holotype, two small immature (? or microconchiate) specimens and one fragment of a large phragmocone from WA 11 at 30 m; one small immature (? or microconchiate) specimen from USGS 19862. All are internal molds with test remains from the *S. sowerbyi* Zone of the Kialagvik Formation, Wide Bay.

Diagnosis.—An involute species of *Pseudolionoceras* with strong umbilical ridge, tabulate-unicarinate venter, striate costae and weak intercalatories.

Description.—The whorls are involute and strongly compressed. The innermost whorls, up to approximately 15 mm diameter, are compressed-oval as in most other species. Subsequent-



Text-fig. 20.— Scatter for relative umbilical width ($U:D$) of *Pseudolioceras costistriatum*, n. sp. (circles, H = holotype) and *P. macintocki whiteavesi* (White) (dots with visually drawn central line). Note the narrower umbilicus of the new species.

ly, the umbilical slope heightens and the margin raises to form an increasingly strong umbilical edge; the maximal whorl width lies approximately in the middle of the flattened sides; the venter becomes distinctly tabulate-unicarinate at about 25 mm diameter and sometimes even somewhat bisulcate on the mature phragmocone; the hollow-floored keel is not strong but well defined.

The ornament consists of blunt typically falcate principal costae tending to become obsolete on the inner flank. The flattened outer costae are striated superficially, often appearing as costellae compounds, and sometimes weakly fasciculate on the inner whorls. The falcate striae or costellae bundles are also present on the internal mold of the relatively large holotype, particularly on the shoulders where they appear as faint intercalated secondaries, and also appear irregularly on the middle of the sides. A single concave outer rib is sometimes intercalated.

The septal suture is of moderate complexity and resembles that of other *Pseudolioceras*.

Comparison.— *P. costistriatum* somewhat resembles *P. macintocki* (Haughton) and particularly the subspecies *P. m. whiteavesi* (White) from which it is distinguished by the narrower umbilicus, the tabulate-unicarinate venter, and the falcate striae or costellae.

The only known *Pseudolioceras* with tabulate-unicarinate venter is the early Toarcian *P. subconcauum* Buckman which differs strongly in coiling and costation. This species is almost homeomorphous with the penecontemporary *Stauffenia* (*Hyperlioceras*) which is absent from the Americas; there can be no question, however, that this is a *Pseudolioceras* and thus the latest representative of the Harporceratinae.

Measurements. —

	Dmm	W%	H%	U%	S
Holotype (body ch.)	68	24	50	13.5	20
" " " "	50	26	52	14	—
J1056a (juv.?, body ch.)	34	26.5	—	—	22
" " " "	23	29	46	17.5	—
USNM 160925	22.5	29.5	47	18	23

Subfamily **Grammoceratinae** Buckman, 1904

Genus ***Asthenoceras*** Buckman, 1899

Type species. — *Grammoceras nannodes* Buckman, 1890 [lectotype here designated: pl. 33, figs. 13, 14; refigured in Arkell, 1957, p. L 261].

The type species was based on only two specimens from the Inferior Oolite of southern England, both of which were derived from older collections not made by the species author. The better preserved specimen came from an unknown horizon of Stoford in Somerset [lectotype], the other from Bradford Abbas in Dorset supposedly without doubt from the "Paving bed" (= *L. murchisonae* Zone s. s.) according to the lithology of its matrix. A few years later, Buckman (1899, p. 49) erected the genus *Asthenoceras* on these two specimens. He named as diagnostic features the small size, the compressed widely umbilicate whorls, the laterally sulcate hollow-floored keel, and the fine ornament consisting only of dense striae. The septal suture was unknown.

With only 24 and 25 mm respective diameters, the two "co-types" of *G. nannodes* are apparently almost complete and fully grown. The mid-laterally increasingly convex striae suggest strongly that both specimens had lateral lappets and were microconchs (males). The corresponding macroconchs (females) have not yet

been described and are apparently unknown from Europe. This is not surprising if one considers the acute scarcity of *G. nannodes* in the European *L. munchisonae* Zone which abounds in other ammonoids.

Dimorphism is well known in Toarcian *Grammoceras*inae, including *Grammoceras* (cf. Buckman, 1890, pl. 28, figs. 20, 21; pl. 32, fig. 3). However, their microconchs are so similar to the inner whorls of the macroconchs that Buckman did not distinguish them specifically regarding them as the juveniles. These microconchs with lateral lappens are of similar size as '*G.*' *nannodes* which is, however, clearly distinct in the much finer or obsolete ornament and the laterally sulcate keel. The diagnosis of *Asthenoceras* in the Treatise (Arkell, 1957, p. L 261; classified as subgenus) simply as "dwarf *Grammoceras*" is, therefore, insufficient; *Asthenoceras* is not the microconch to any described *Grammoceras*.

The *Asthenoceras* sample from Wide Bay comprising about 20 specimens comes from a single concretion of the *Pseudocidoceras* zonule in the *S. sowerbyi* Zone. Another much larger sample was collected by the author from a single lenticular bed in the uppermost Weberg (or basal Warm Springs) Formation near Supplee in east-central Oregon; the association with evolute *Witchellia* and cf. *Sonninia* (*Euhoploceras*) is as in Alaska and indicates *S. sowerbyi* Zone. However, R. Imlay from the U.S. Geological Survey recently showed the author rich collections of *Asthenoceras* from the *O. sauzei* Zone of the Warm Springs Formation at approximately the same Oregon locality. The Oregon species varies greatly in size and suggests the development of dimorphism.

The largest Oregon specimens of 50-70 mm diameter resemble typical *Grammoceras* ex gr. *G. striatulum* (Sowerby) in the compressed oval whorl section and evolute coiling but are distinct in the laterally sulcate high keel. A number of species usually classified as *Grammoceras*, such as *G. fallaciosum* (Bayle), have high hollow-floored keels but these have never been observed to be laterally sulcate. The Wide Bay species consists of two size groups, i.e. about 15 mm large microconchs with small lappets and 30-35 mm large macroconchs with somewhat modified ornament on the last whorl. These extremely small adult sizes compare with average

diameters for *Grammoceras* of 25-40 mm for microconch and 60-120 mm for macroconchs (cf. Buckman, 1890, pls. 27-20). There is little doubt that both samples represent single dimorphic species which cannot reasonably be split taxonomically; the Wide Bay form is here described as the single species *Asthenoceras* aff. *A. nannodes*. Because the macroconch of the Dorset species is unknown, a definite identification with that species is not yet possible.

The author has long pondered whether to elevate *Asthenoceras* to generic level or whether to retain it as a subgenus of *Grammoceras*. Preference is now given to the generic level for the following reasons:

1. The high, laterally sulcate keel is unique.
2. The ornament is much finer than in *Grammoceras*.
3. The great difference in age from *Grammoceras* (and its abundance as dimorphic species in North America).

Furthermore, the juvenile whorls are probably more widely umbilicate and more compressed than in other grammoceratids. The simplified suture (here described for the first time) is of a generalized nature, *i.e.* conforming with some grammoceratids but not restricted to them. There is close resemblance in the dense, strongly projected and partly fasciculate growth lines with the even less known *Vacekia stephensi* Buckman (1899), placed in the Graphoceratidae by Arkell (1957, p. L 262); this species is from the *L. munchisonae* Zone of the Inferior Oolite and distinguished in the different coiling, whorl shape and keel. It appears that *Asthenoceras* belongs to a "conservative stem" of Hildoceratidae, which includes *Arieticerias* and *Grammoceras*. It is of interest that in the Pliensbachian Arieticeratinae a similar almost smooth and compressed form was produced as an early offshot, *i.e.* *Asaploceras*.

Middle Jurassic Hildoceratidae above the *L. opalinum* Zone are essentially restricted to the Pacific realm. Of the Harpoceratinae, *Pseudolioceras* occurs in northwestern North America and probably in Japan (Westermann, 1964, p. 351). Of the Grammoceratinae, *Asthenoceras*, previously known only in two specimens questionable from the *L. munchisonae* Zone of Dorset, is locally abundant in Oregon and southern Alaska. It is probably significant that both are long ranging genera, *i.e.* *Pseudolioceras* ranging from

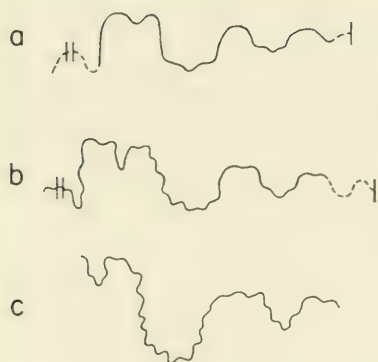
the upper Toarcian to the *S. sowerbyi* Zone and probably from the *L. murchisonae* Zone to the *A. sauzei* Zone. *Tmetoceras* reaches at least to the top of the Aalenian in southern Alaska, Oregon (?), the southern Andes (Westermann, 1967) and probably Thailand (Komalarjn and Sato, 1964). *Pleydellia* (s.l.), which is probably the latest wide-spread member of the Grammoceratinae in Europe where it ranges into the lower *L. opalinum* Zone, has also been described from the lower Aalenian of a single locality in the Canadian Arctic (Frebold, 1960, p. 23, pl. 12, figs. 1-4). However, the disputed "*Pleydellia assemblage*" (or '*P. puchensis* group') of Mendoza in the southern Andes (Burckhardt, 1903, pls. 1, 2) is tentatively placed in advanced Hammatoceratinae or very early Sonminiidae.

Asthenoceras sp. aff. **A. nannodes** (Buckman) 1890, ♂ & ♀
Pl. 14, figs. 1-7, Text-figs. 21a-c

Material.—Four almost complete macroconchs, three complete and two fragmental microconchs with lappets, and about a dozen incomplete, juvenile or fragmentary specimens; all from a single concretion of WA 10 at 11 m (J 1037, J 1035) in the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description.—Following the first globose whorl, the probable larval stage, the coiling becomes widely umbilicate; the whorl section changes from sub-circular to somewhat compressed oval to fastigate (at 3 mm D) and to strongly compressed oval and keeled (5-6 mmD). Finally, at 10-12 mm diameter, the adult size of the microconchiate phragmocone, the sides are somewhat flattened curving sharply to the umbilical seam and into the usually rounded but sometimes narrowly tabulated externside which carries a strong blunt keel.

The microconchiate (♂) body chamber is about one-half whorl long and terminates at only 15-16 mm diameter with lateral lappets. Beside the slight egression of the umbilical seam, there is no significant modification. The macroconchiate (♀) phragmocone grows to about 22-25 mm diameter, becoming even more compressed with narrowly convex externside and exceptionally high and narrow hollow-floored keel. The keel attains the typical laterally



Text-fig. 21 a-c.—Septal suture of *Asthenoceras* sp. aff. *A. nannodes* (Buckman), compiled from three specimens of a single concretion, loc. WA 10 in the *Pseudocidoceras* zonule, magnified. a. At 10 mm D (McM J 1035). b. At 12 mm D (McM J 1036). c. At 22 mm D, largest available phragmocone diameter (McM J 1035a).

sulcate cross section on the last phragmocone whorl. The body chamber was originally at least one-half whorl long terminating at 32-36 mm diameter. Although not preserved, the aperture was probably simple in accordance with the reduction in flexure of the growth lines at the end of the preserved body chambers.

The ornamentation of the inner whorl is faint, largely superficial, and develops only after 5-7 mm diameter. It consists of slightly flexed, strongly projected, extremely fine striae representing growth lines and often also of widely spaced similarly flexed bundles of striae or obscure plications which could represent poorly developed costae.

On the microconch, these growth lines and striae bundles continue onto the body chamber where they become falcid by increase of mid-lateral convexity indicating the gradual development of lateral lappets. The few preserved short and narrow lappets, positioned at about two-fifths whorl height, are probably all more or less incomplete. The internal mold of the microconch is either entirely smooth or bears similar weak irregular striae as the surface of the shell. The striae sometimes continue onto the keel giving it a braided appearance.

The macroconch develops densely spaced strongly projected costae on the last whorl. The costae are usually restricted to the outer flanks and some specimens bear a few blunt plications on the inner flanks which arise from costae fasciculation. Falcid growth lines are also common. Towards the end of the body chamber, costae and growth lines become less flexed and some-

times straight. The most complete specimen (Pl. 14, fig. 5a, b) has five-eighths whorls of preserved body chamber which toward the end bears almost rectiradiate and complete, widely spaced blunt costae. These macroconchs are fully grown according to the approximation of the last septa.

The septal suture (Text-fig. 21) is extremely simple, even considering the small size. At 10 mm diameter (3.5-4 mm H) only the large E/L saddle (externsaddle) and the L and U₂ lobes ("1st. and 2d lateral lobes") are frilled, at the first order only. At 12 mm diameter, the suture is still subammonitic. A suture observed at the diameter of 22 mm is only slightly more complex, with second-order frilling only of the E/L saddle. E and E/L are large, U₂ decreases ontogenetically in relative size. There are one or two more small external umbilical elements of regularly decreasing size. The internal part of the suture is unknown.

Comparison.—The microconch of the Wide Bay species resembles the "cotypes" of *A. nannodes* Buckman. They differ in the smaller size (about 15 mm *vs.* about 25 mm D) and possibly also in the more regularly bundled costae if developed.

Because the Dorset species is poorly known and represented by the microconch only, no definite judgment as to the affinity between the Dorset and Wide Bay forms is possible, and the latter can only be tentatively referred to *A. nannodes*.

The Oregon form is much larger than the Wide Bay form and retains the dense ornament up to the body chamber of the macroconch.

Measurements.—

	Dmm	W%	H%	U%	S
J1035a (body ch.)	33	23	32	42.5	c.35
(phragm.)	22	24	35.5	41	—
J1037 (aperture)	15	24	33	38.5	—
(phragm.)	10	28	37	36	—

Family **Hammatoceratidae** Buckman, 1887

Subfamily **Hammatoceratinae** Buckman, 1887

Since the first part of this monograph went into press, the two important monographs on Middle Jurassic Hammatoceratinae by Elmi (1963) and Géczy (1966), as well as the smaller works by Sapunov (1964), Bremer (1966) and Blaison, *et al.* (1966)

have been published, based on assemblages respectively from France, Hungary, Bulgaria, and Turkey. The study of Moroccan hammatoceratids by Lelievre (1960) had been overlooked by me. Furthermore, a taxonomic revision of the Hammatoceratidae based on ontogenetic studies of the septal sutures was carried out by Schindewolf (1964). The following five new generic and subgeneric names have been given since 1964:

Genus *Pseudammatoceras* Elmi, 1964, p. 13; type species: *Ammonites subinsignis* Oppel, 1856 (Renz, 1925).

Subgenus *Eudmetoceras* (*Rhodaniceras*) Elmi, 1964, p. 60; type species: *Hammatoceras rhodanicum* Renz, 1925 (for "*Hammatoceras subinsigne*" Bayle, non Oppel). Microconchs to *Eudmetoceras* s.s.

Genus *Spinammatoceras* Schindewolf, 1964, p. 340; type species: *Hammatoceras pugnax* Vacek, 1886. Microconchs.

Subgenus *Hammatoceras* (*Pseudaptetoceras*) Géczy, 1966, p. 77; type species: *Harpoceras klimakomphalum* Vacek, 1886; lectotype designated Sapunov, 1964: Vacek's figs. 17, 17a.

Subgenus *Hammatoceras* (*Csernyeiceras*) Géczy, 1966, p. 83; type species: *Hammatoceras werpillierense* Roman and Boyer, 1923.

At least 19 new species names were given and a number of infra-specific taxa named by Elmi (1964) and Géczy (1966) for keeled Middle Jurassic Hammatoceratinae [exclusive of *Erycites*, *Abbasites*, and *A. (Ambersites)*]. Both authors considered *Abbasites* generically distinct from *Erycites*, in contrast to the Treatise (Arkell, et al., 1957, p. L 267) but in conformity with this monograph (Westermann, 1964a, p. 404). However, Elmi and Lelievre differed greatly from Géczy in the classification of the keeled hammatoceratids, particularly with respect to taxonomic level. While Géczy included all keeled Middle Jurassic hammatoceratids in the single genus *Hammatoceras* with two old and two new subgenera, Elmi and Lelievre retained almost all the genera of Buckman. Géczy (p. 31) also doubted the generic distinction of *Erycitoides* Westermann, 1964. This judgment was based only on my preliminary abstract (Proc. 1st. Coll. Juras., 1964) and later withdrawn after study of the monographic description (oral communication at 2d Coll. Juras., 1967). More particularly, Géczy regarded as synonyms of *Hammatoceras* the "genera" *Bredyia* Buckman, 1910, *Eudmetoceras* Buckman, 1920, *Pachammatoceras* Buckman, 1921, *Planammatoceras* Buckman, 1922, *Parammatoceras* Buckman, 1925, *Pseudammatoceras* Elmi, 1963, and the subgenus *E. (Rhodaniceras)* Elmi, 1963. [For *Erycitoides* and *E. (Kialagvikites)* Wester-

mann, 1964, see above]. Géczy's (1964) "*Hammatoceras s. str.*", therefore, included all previously named keeled *Hammatocera*-tinae except for *Euaptetoceras* Buckman which was retained as subgenus only because of the supposedly asymmetrical lateral lobe (L). Géczy then proceeded to distinguish two new subgenera of *Hammatoceras*, again on sutural characters, i.e. *H. (Csernyeiceras)* with large E and *H. (Pseudaptetoceras)* with alleged relatively simple suture and symmetrical L in comparison with *E. (Euaptetoceras)*.

I have not arrived at any definite opinion regarding the classification of many of the early and intermediate *Hammatocera*-tinae. Taxonomic levels somewhere midway between the ones above reviewed are strongly suggested, similar to the treatment in the Treatise (Arkell, *et al.*, 1957, p. L 267), to the tentative classification in the first part of this monograph and to the recent usage by Bremer (1966), Sapunov (1964), and Blaison, *et al.* (1966).

Hammatoceras (s.s.?) Hyatt is perhaps reasonably diagnosed and defined in the Treatise (p. L 267) as including the synonym *Pachammatoceras* and as being confined to the upper Toarcian. *Pseudammatoceras* Elmi comprising early Aalenian species grouped around the type species *P. subinsigne* (Oppel), however, appears close to *Bredyia* which was not even mentioned by Elmi. It is possible that Arkell, *et al.*, in the Treatise meant to include these forms in *Bredyia* because this is the only genus listed from the *L. opalinum* Zone. *Bredyia* and perhaps also the related *Pseudammatoceras s.s.* could be classified as subgenera of *Hammatoceras*, but later species of Elmi's *Pseudammatoceras* are much closer to the dubious '*Parammatoceras*' and even to *Planammatoceras* (see below).

Planammatoceras Buckman should be generically distinguished from *Hammatoceras*, but it cannot be defined to nontuberculate forms as in the Treatise (Arkell *et al.*, 1957; p. L 267). This author (Westermann, 1964, p. 411) and Elmi (1963, p. 89) included in *Planammatoceras* the widely umbilicate and tuberculate "*H. lorteti* Vacek, non Dumortier" (= *P. romani* Elmi). There is a good possibility that *P. tenuinsigne* (Vacek) and *P. planiforme* Buckman which were previously regarded synonymous with *P. planinsigne* (Vacek) (*loc. cit.*) are but the compressed and finely ornate end-

members of an intergrading penecontemporaneous morphological sequence, *i.e.* a single species, with the other widely umbilicate and strongly ornate end-member being named *P. romani* Elmi. Such a morphological sequence would conform with the "Buckman law of covariation" (Westermann, 1966).

However, the distinction of *Planammatoceras*, flourishing in the *L. murchisonae* Zone, from typical *Eudmetoceras* of the *L. concava* and lower *S. sowerbyi* Zones is ill-defined, and I am still hesitant to take a more definite stand regarding their taxonomic separation on the generic level than I did in the first part of this monograph (Westermann, 1964a, p. 412). The genus *Planammatoceras* is, therefore, tentatively retained.

Eudmetoceras (*s.s.*) is certainly not sufficiently characterized by "un enrolement evolute et par leur ombilic plat" (Elmi, 1963, p. 59). A steep umbilical wall is usually present in *Eudmetoceras* which, in contrast to many *Planammatoceras* of similar whorl section and coiling, results in a stepped umbilicus. A distinctive character of *Eudmetoceras* could be the numerous long, often fasciculate primaries and the strong secondaries of the juvenile whorls (cf. 1-3 cm D). However, if tubercles or nodes are present, the costation seems to resemble some "*Parammatoceras*." I am unable to find any significant difference in the septal suture between the type species *E. eudmetum* Buckman and similarly shaped other Aalenian *Hammatoceratinae*, although some apparently related species have simpler and less suspensive sutures. The classification of the Andean '*Hammatoceras*' *gerthi* Jaworski and '*E. eudmetum*' *jaworskii* Westermann is now being reinvestigated by the author based on new material.

A brief study of Buckman's collections from Bradford Abbas in Dorset (Geological Survey Museum, London) in December 1964, has confirmed my earlier expressed opinion (Westermann, 1964a, p. 409) that '*E. euaptetum*' Buckman, the type species of *Eudmetoceras* (*Euaptetoceras*), cannot specifically be separated from '*Harporoceras*' *amalthaeiforme* Vacek. *E. (Euaptetoceras)* *amplectens* Buckman appears clearly distinct from *E. amalthaeiforme* in the rounded umbilical margin and smooth inner flank throughout growth although the rare occurrence of intermediate forms cannot be ruled out. The flanks of *E. amplectens* are flat and subparallel

to slightly convergent while the umbilical margin and venter are broadly rounded (test also keeled) at least up to approximately 7 cm in diameter. The identification of '*E. amplexans*' of Maubeuge (1955, pl. 6, figs. 4, 5) with *E. klimakomphalum* (Vacek) by Géczy (1966, p. 78) is, therefore, probably correct. The coiling of *E. (Euaptetoceras)* becomes progressively more involute during growth with the juvenile whorls resembling *E. (Eudmetoceras) eudmetum*. Furthermore, the simple strong costation is similar as in juvenile *E. eudmetum* and *E. (Rhodaniceras) Elmi*, the supposed microconch. However, juvenile resemblance in whorl section is closer to *E. infernense* (Roman) because of absent sulci. Thus, the small *E. infernense* could be the corresponding microconch to *E. amaltheiforme*. The secondary costae of '*E. euaptetum*' vary from rectiradiate and weakly projected to slightly falcoid; these variable features were used by Elmi (1963, p. 101) to distinguish *E. amaltheiforme* from '*E. euaptetum*.'

Lelievre (1960, p. 34) distinguished the more widely umbilicate *Eudmetoceras* (s.s.) from the narrowly umbilicate (at least when fully grown) *E. (Euaptetoceras)* at the generic level based on allegedly significant differences in the septal suture; i.e. the former supposedly with a more central position of a symmetrical L and three U elements, the latter with more ventrally located asymmetrical L and four U elements. The positional differences of L have already been judged as insignificant on the basis of measurements by Géczy (1966, p. 77). I regard this multiplication of umbilical elements (by subdivision of U_3 or by introduction of new U lobes) and the corresponding ventrad shift of L as a direct functional dependant of the increase in whorl overlap and not as a significant "genetical" character of taxonomic significance. A similar inter-relation may influence the suspension of the umbilical lobes, the suspension angle (between "saddle line" and radius) being usually reduced in greatly overlapping (involute) whorls without significant differences in total suspension. Furthermore, the less incised suture of the microconchiate *E. (Rhodaniceras)* can probably be explained by the small size and is expected to be matched by juvenile *Eudmetoceras*. The reference to the asymmetry of L in *Euaptetoceras* (Lelievre, 1960, p. 34, Géczy, 1966, p. 29) was based solely on Buckmans' figure (1922, pl. 299) of the holotype of

'*E. euaptetum*' and appears to be no more than a mere irregularity. Finally, the specimen figured by Maubeuge (1955, pl. 6, fig. 3) under the same name appears to have a symmetrical L. No other specimens labelled as '*E. euaptetum*' were found in Buckman's collection of the Geological Survey Museum, nor am I aware of any other descriptions of this alleged species from England. Lelievre's (*loc. cit.*) supposition that these differences were also present in Moroccan specimens, contradicts his statement (p. 35) that the septal suture was not preserved.

The close affinity between juvenile *Eudmetoceras* s. s. and *E. (Euaptetoceras)* may be retained up to the late adolescent stage so that incomplete shells are difficult to classify. A case in point is *E. nucleospinosum* Westermann from the *E. howelli* Zone which is now transferred from the former to the latter subgenus. *Euaptetoceras* is, therefore, included as subgenus in *Eudmetoceras*, as in the first part of this monograph.

The subgenus *E. (Pseudaptetoceras)* Géczy can be retained beside *E. (Euaptetoceras)* only if the type species '*Harpoceras*' *klimakomphalum* Vacek is sufficiently distinct from *E. (Euaptetoceras)* *amalthaeiforme* to warrant subgeneric rank. The respective type species, however, were included in the same subgenus by apparently all previous authors, including Elmi (1964) and Géczy (1966). However, I suggested earlier (Westermann 1964a p. 410) that '*H.*' *klimakomphalum* is a strigoceratid on the strength of the "lanceolate" whorl shape and the occurrence of strongly projected growth lines and spiral markings on Wide Bay specimens. Other strigoceratid characters of '*H.*' *klimakomphalum* are the small umbilicus with steep umbilical walls and the reduction of primaries; possibly a "prerequisite" for the occurrence of striae. Further studies have now revealed that (1) weak and irregular concentric markings are present on only a single specimen of the Wide Bay assemblage, (2) similar markings or weak striae are also known from *E. amalthaeiforme* (the holotype, Vacek, 1886, pl. 9, fig. 1) and *E. verpillierense* Roman and Boyer (*priv. com.* Elmi), (3) the costation is markedly falcate at least on the immature whorls of strigoceratids while it is straight to slightly falcoid in the *E. klimakomphalum* group, (4) the growth lines are rarely preserved and therefore poorly

known in hammatoceratids, (5) the E lobe is usually larger in strigoceratids (priv. com. Géczy, 1966), (6) the Wide Bay sample shows apparent intergradation of the narrowly umbilicate forms with those having more widely umbilicate and, significantly, tuberculate inner whorls, and (7) the umbilicus of the body chamber opens as in hammatoceratids while remaining small in strigoceratids. I, therefore, conclude, in agreement with Dr. Elmi's tentative opinion (priv. com., based on photographs), that the suboxycone forms from the *S. sowerbyi* Zone of Wide Bay and *H. klimakomphalum* are Hammatoceratinae and are to be placed in *Eudmetoceras*.

Nevertheless, the resemblance of the suboxycone or discoidal hammatoceratids of the *E. klimakomphalum* group from the *L. concava* and *S. sowerbyi* Zones to early strigoceratids such as the contemporary *Praestrigit*es Buckman (but probably flourishing slightly later) is considered to reflect phylogenetic relationship. Hence, the Strigoceratidae are probably derived from *Eudmetoceras* rather than from Oppeliidae or Graphoceratidae as recently suggested by Schindewolf (1964, pp. 367, 430). The resemblances of Strigoceratidae to Sonniniidae (Scheurlen, 1928, p. 37; Schindewolf, 1964, p. 430) can be explained with their common origin in the Hammatoceratinae.

Concerning the alleged subgenus *E. (Pseudaptetoceras)* Géczy, several contemporary species morphologically intermediate between the type species *E. (P.) klimakomphalum* (Vacek) and typical *E. (Euaptetoceras)* are known. *E. infernense* (Roman) has the narrowly rounded externside of *E. klimakomphalum* but stronger primaries and a much wider umbilicus. *E. amplexens* (Buckman) is also involute but differs in the rounded umbilical slope and broad externside, apparently with much variation, as well as in the smooth inner flanks. *E. tyrrenicum* (Renz) appears to have the whorl shape of *E. klimakomphalum* but the ornament of *E. amplexens*. Furthermore, broadening of the externside and rounding of the umbilical walls appears to be highly variable in other, earlier Hammatoceratinae such as *Planammatoceras planinsigne* (Vacek) where the whorls can become almost fastigate. Umbilical width which is at least partly correlated with whorl section, appears to vary greatly intra-specifically as well as inter-specifically

between apparently close relatives. This is also indicated in the Andean presumed hammatoceratids [*'Pleydellia'* auct.] figured by Burekhardt (1900, pl. 20; 1903, pl. 1, 2), all of which differ, however, from typical hammatoceratids in the much simpler septal suture and the low keel. Suture simplification ("degeneration") may be present to a small degree in *E. klimakomphalum* and appears to be a common feature among late hammatoceratids; the significance of this character remains doubtful. Consequently, if *Pseudaptetoceras* were retained as a subgenus of *Eudmetoceras*, the type species would be its only certain species. *'Oppelia' moerickei* Jaworski and *'Hammatoceras' discus* Merla are tentatively included in the type species. However, *E. klimakomphalum renzi* Elmi (1963, p. 79, pl. 10, fig. 2) differs by the broad externside, the larger umbilicus ($19\% \text{ vs. c. } 14\%$) and the coarser costation and appears closer affiliated to *E. amaltheiforme*. *'Deltotoceras' corroyi* Gerard, placed in the species-group of *E. klimakomphalum* by Elmi (1963, p. 101), has few widely spaced primaries and could be an involute member of the *'H.' sieboldi* (Oppel) group. Consequently, the subgenus *H. (Pseudoptetoceras)* is tentatively considered synonymous with *E. (Euaptetoceras)*. This opinion is shared by Blaison, *et al.* (1966, p. 101).

Still unsolved is the taxonomic position of *Parammatoceras* Buckman, 1925, which was placed in synonymy with *Planammatoceras* by Arkell, *et al.* (1957), p. L 267) but with *E. (Euaptetoceras)* by the present author (1964a, p. 409) on the grounds that the holotype of the type species *P. obtectum* Buckman (not *P. rugatum* Buckman as erroneously stated in *loc. cit.*) is indistinguishable from the holotype of *'E. euaptetum'* [= *E. amaltheiforme* (Vacek)]. Bremer (1966, p. 158) supported this opinion. This statement does not necessarily imply that the species or subgenera are synonymous. The whorl sides are flattened converging only slightly and the externside is broad. Also the inner whorls as seen in the umbilicus ($\cong 3.5 \text{ cm D}$) of the plastotypes of both type species are similarly evolute with flat inner flanks and vertical umbilical wall and have the same dense primaries without tubercles. There may be a slight difference in the costation of the ultimate phragmocone whorl, the secondaries being born by furcation in *'P. obtectum'* rather than by fasciculating as in *'E. euaptetum'*.

The following measurements were made on the plastotypes.

	D	H%	W%	U%	P	S(1/4 whorl)
' <i>Euaptetoceras euaptetum</i> ' holotype (plastotype)						
(phragm.)	12.8 cm	45	26	21	12 (at 7.5 and c.5 cm D)	17
' <i>Parammatoceras obtectum</i> '—holotype (plastotype)						
(phragm.)	18.5	48	26	18.5	—	—
"	14.5	47	—	19.5	—	—
"	11.5	45.5	27	21	12	18-19

There is no evidence for "ogivale" (like a gothic arch) whorl section or tuberculate inner whorls of '*Parammatoceras obtectum*' as assumed by Elmi (1963, p. 95) who included in this genus a seemingly diverse group of known and newly named species from the *L. opalinum* and *L. murchisonae* Zones. Some of these species are moderately evolute, partially nodose forms with oval whorl section which are grouped about '*H.* *sieboldi* (Oppel) [*"P. obtectum* Buckman" in Elmi, pl. 6, fig. 1; *P. richei* Elmi]. In Alaska, *E. nucleospinosum* Westermann appears to be morphologically intermediate between '*H.* *sieboldi* and *Eudmetoceras* so that I previously assumed a close relationship between '*H.* *sieboldi* and *Eudmetoceras* (Westermann, 1963a, p. 410); these resemblances are now thought to be probably due to convergence. In studying Elmi's monograph (1963), one soon becomes aware that other more evolute and compressed species placed by him in '*Parammatoceras*' are closely affiliated with *Planammatoceras* [*op. cit.*: '*Parammatoceras* *auerbachense* (Dorn), pl. fig. 2 and '*P.* *boyeri* Elmi, pl. 7, fig. 1; compare with *Planammatoceras planiforme* (Buckman) (pl. 11, fig. 1) = *P. planinsigne* (Vacek), *P. dubari* (Maubeuge) and *P. romani* Elmi] although the nuclei may be distinguished by bullae-like strong primaries. The widely umbilicate '*P.* *rochei* Elmi (pl. 5, fig. 2) resembles closely *Eudmetoceras* (*Eudmetoceras*) *masticonnensis* Elmi, (pl. 9, fig. 5) as well as several widely umbilicate *Pseudammatoceras* species of Elmi, *i.e.* *P. grandis*, *P. mouterdi*, and *P. rugatum* Buckman which Buckman placed in *Parammatoceras*. The unusual oblique bullae of '*Parammatoceras suballeoni*' Elmi and of the closely affiliated '*P.* *alleoni*

Dumortier (Elmi, 1963, pl. 8) are also present in the closely grouped early Aalenian group of *Pseudammatoceras ornatum* Elmi, *P. guliense* (Renz), *P. dumortieri* (Prinz), and probably *P. subinsigne* (Oppel), type species of *Pseudammatoceras* Elmi.

The dubious '*Parammatoceras*' appears to be synonymous with *E. (Euaptetoceras)* unless investigations on new material from the type locality and type stratum can demonstrate that the inner whorls of the large type species *P. obtectum* are significantly different from those of the *E. amaltheiforme* group and, instead, resemble those of the *H. sieboldi* group, as implied by Elmi. By placing *P. rugatum* in '*Parammatoceras*', Buckman implied strongly nodose immature whorls. However, Elmi's transfer of this species to his new genus *Pseudammatoceras* seems to indicate that either Buckman's classification was wrong or that '*Parammatoceras*' as understood by Buckman intergrades with *Pseudammatoceras*. Consequently, it appears advisable for the time being (1) to consider '*Parammatoceras*' a *nomen dubium*, (2) to tentatively transfer the lot of the species included in '*Parammatoceras*' by Elmi (1963) to *Pseudammatoceras*', and (3) to tentatively classify *Pseudammatoceras* as a subgenus of either *Planammatoceras* or *Hammatoceras*. The creation of yet another taxon is certainly inadvisable.

Csernyeiceras Géczy, based on *Hammatoceras verpillierense* Roman and Boyer, appears to be well separated on the base of whorl section and septal suture.

Genus **EUDMETOCERAS** Buckman, 1920

Subgenus **EUDMETOCERAS (EUDMETOCERAS)** Buckman, 1920

Eudmetoceras (Eudmetoceras) sp. aff. **E. eudmetum** Buckman, 1920

Pl. 15, figs. a,b

1964. *Eudmetoceras* (s.s.) cf. *E. eudmetum* Buckman, Westermann (Wide Bay), Bull. Amer. Paleont., vol. 47, p. 409.

Material. — One large phragmocone whorl and one small fragment of another large phragmocone, well-preserved internal molds from USGS 21251 (USNM 160926). *Pseudocidoceras* zonule, *S. sowerbyi* Zone, Wide Bay, Alaska, Peninsula.

Description. — The phragmocone whorl of 12.7 cm diameter is widely umbilicate (U 38%) and compressed oval in section with narrow steep umbilical slope. The externside of the internal mold

is narrowly rounded, almost fastigate, and shows remnants of a narrow sharp hollow-floored keel. The costation is strong becoming somewhat blunt toward the end of the preserved phragmocone. The ultimate half whorl carries nine somewhat bullae-like, rectiradiate primaries which bifurcate or trifurcate at about two-fifths whorl height. There are 28 partly intercalated, markedly convex and strongly projected secondaries on the ultimate halfwhorl which reach the smooth narrow median band (internal mold) at an angle of about 45° (corresponding to a ventral costae angle of 90°).

Septum and suture are well preserved. The septum is planodisculate; the intensely incised sutures (Pl. 15, fig. a) are terminally not markedly approximated, indicating that the phragmocone is incomplete. The other fragmentary specimen has approximated sutures and blunt costation at about 17-20 cm diameter. All lobes are slender with long thin stems. L and E are equally deep, the L/U_2 saddle is almost as high but only $2/3$ as wide as E/L , U_2 is narrow, asymmetric and somewhat oblique; U_3 (? + U_4) is strongly suspensive consisting of two major external indentations (or lobes?). The saddle boundary is therefore strongly bent with the kink over L/U_2 . The internal suture has a single dominant U/I saddle and adjacent strongly suspensive subdivided umbilical elements.

Comparison.—The incomplete Wide Bay specimen resembles the corresponding ultimate halfwhorl of the holotype of *E. eudmetum* [plastotype studied] although the latter is preserved with the shell. The only differences are in the slightly wider umbilicus, the stronger more widely spaced primaries and the somewhat stronger flexed secondaries of the Wide Bay specimen (see measurements below). Buckman's paratype, a topotype from the *L. discites* Subzone of Bradford Abbas in Dorset, which is much larger and has an incomplete body chamber, has even closer set primaries. However, the inner whorls up to eight cm diameter of the Wide Bay form are unknown.

Eudmetoceras masticonnensis Elmi (1963, p. 69, pl. 9, figs. 5a, b) from the *L. discites* Subzone of Maconnais, France, is distinguished from the type species by the nodose inner whorls, which are not preserved in the Wide Bay specimen, and the stronger bullae-like primaries of the phragmocone of comparable size (see

measurements below). The Wide Bay form may, therefore, be closer affiliated with this newly described contemporary and possible subspecies of *E. eudmetum*.

The Andean *Eudmetoceras* ? *gerthi* (Jaworski) and *E.?* *jaworskii* Westermann need further study before comparison can be made.

Remarks.—A close although possibly only superficial resemblance exists to *Erycitoides howelli* (White) from the underlying *E. howelli* Zone. However, the latter has a broadly rounded externside with a low solid keel, less curved secondaries, and a simpler less strongly suspensive septal suture.

	Dmm	H%	W%	U%	P	S
USNM. 160926 (phragm.) 127		38	27	38	9	28
(phragm.) 86		36	29	c.38	—	—
<i>E. eudmetum</i> — holotype						
(body ch.) 110		40	26.5	34	c.11	30
(phragm.) 90		83	29.5	35.5	12.5	27
<i>E. masticonnensis</i> — holotype						
(fide Elmi, phragm.) 92		40	26	35	11	30

Subgenus **E. (EUAPTOCERAS)** Buckman, 1922

[Syn. *PSEUDAPTETOCERAS* Géczy, 1966]

Eudmetoceras (Euaptetoceras) klimakomphalum (Vacek), 1866

1886. *Harpoceras klimakomphalum* n. sp., Vacek (Alps), Abh. K.K. Geol. Reichsanst., vol. 12, No. 3, p. 81, pl. 8, figs. 16, 16a, 17, 17a [lectotype figs. 17, 17a].

?1886. *Harpoceras amaltheiforme* n. sp., Vacek, *id.*, pl. 9, figs. 2, 2a only.

(?)1902. *Hammatoceras discus* n. sp., Merla (Appennine), Paleont. Ital., vol. 34, pl. 2, figs. 1, 2.

(?)1926. *Oppelia moerickei* nom. nov., Jaworski (Argent.), Actas Acad. Nat. Sci. Cordoba, pl. 3, fig. 13 (? non fig. 12, lectotype) [subsp.]

(?)1955. *Eudmetoceras amplexens* Buckman, Maubeuge (Switz.), Mém. Suisses Paleontol., p. 34, pl. 6, figs. 4, 5.

1966. *Hammatoceras (Pseudaptetoceras) klimakomphalum* (Vacek, 1886), Géczy (Hungary), Geol. Hung., fasc. 34, p. 78, pl. 19, fig. 2; pl. 40, fig. 11, text-fig. 65.

1966. *Hammatoceras (Pseudaptetoceras) klimakomphalum paenamplexens* n. subsp., Géczy, *id. ac.*, p. 81, pl. 24, fig. 1, pl. 40, fig. 14, text-fig. 68.

?1966. *Hammatoceras (Pseudaptetoceras) amaltheiforme* (Vacek, 1886), Géczy, *id. ac.*, p. 82, pl. 21, pl. 41, fig. 5; text-fig. 69.

(?)non 1900. *Harpoceras klimakomphalum* Vacek, Burekhardt (Argent.), Anal. Museo La Plata, p. 27, pl. 20, figs. 12-14; pl. 29, fig. 3 [copy: Burekhardt, 1903, pl. 2, figs. 1-3].

?non 1963. *Eudmetoceras klimakomphalum* (M. Vacek), 1886, *renzi* nov. subsp., Elmi (France), Trav. Lab. Géol. Lyon, p. 79, pl. 10, fig. 2 [= *E. cf. amaltheiforme* (Vacek)].

(?)non 1964. *Eudmetoceras klimakomphalum* (Vacek), Sapunov (Bulgaria),

Trav. Géol. Bulg., Sér. Paléont., vol. 6, pl. 2, figs. 2a-c [= *E. cf. amaltheiforme* (Vacek)].

?non 1966. *Hammatoceras* (*Pseudaptetoceras*) *klimakomphalum involutum* (Prinz, 1904), Géczy, *id.*, p. 80, pl. 20, figs. 1, 3; pl. 40, fig. 13; pl. 51, fig. 1; text-fig. 67 [= *E. cf. amplexens* (Buckman)].

Lectotype (det. Sapunov, 1964, p. 262): Vacek, 1886, pl. 8, figs. 17, 17a. — A probably incomplete phragmocone from the "condensed" lenticular limestone beds at Cap St. Vigilio, Lago de Garda, in the southern Alps. According to Géczy (1966, p. 79), who has seen the type specimens, the costation of the lectotype is somewhat more feeble than represented in Vacek's figure.

Measurements of type specimens according to Vacek (page 81) or to original figures (in brackets). —

	Dmm	W%	H%	U%	P	S
lectotype (phragm.)	59	24	54	13.5	[c.13]	[36]
'cotype' (Vacek, fig. 16) (phragm.)	147	23	47	17	—	[c.40]
<i>E. klimakomphalum</i> ?, juv. (Vacek, pl. 9, figs. 2, 2a)	[21]	[25]	[43]	[21]	[c.13]	[22]

Eudmetoceras (**Euaptetoceras**) **klimakomphalum discoidale** Westermann, n. subsp. Pl. 14, figs. 8, 9; Pl. 16, figs. 1, 2; P. 17, fig. 1; Pl. 18, fig. 1; Text-figs. 22, 24, 25.

Holotype. — Pl. 16, figs. 1a-f; Text-fig. 25; a slightly damaged phragmocone with well-preserved nucleus. Repository: USNM 160927. (Paratype: Pl. 14, figs. 8a, b; a small phragmocone with crushed body chamber. Repository: USNM 160928).

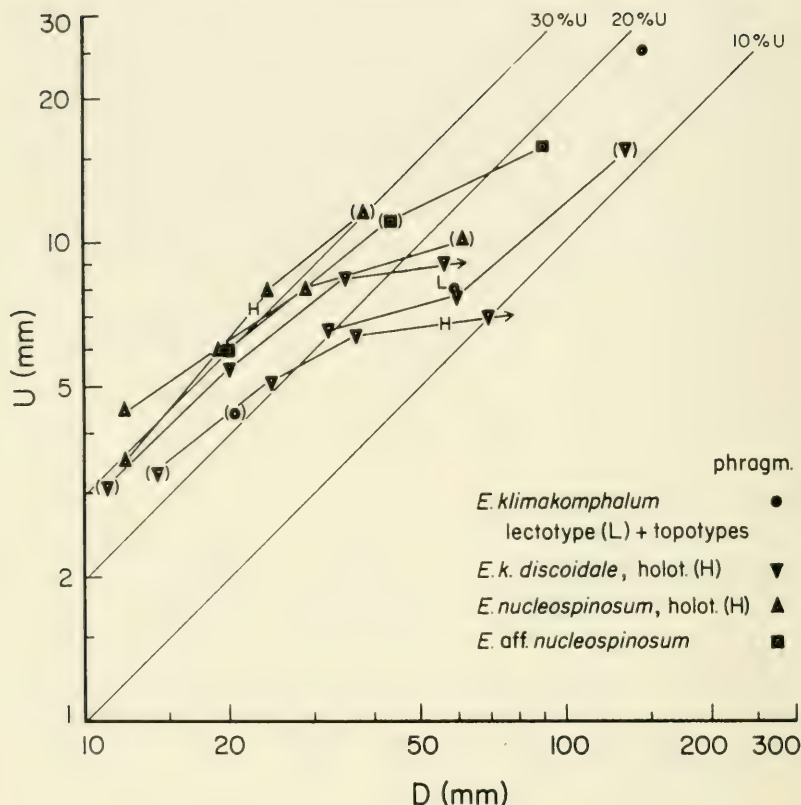
Locus typicus. — U.S. Geological Survey Mesozoic locality 12405 at southeast coast of Wide Bay, Alaska Peninsula.

Stratum typicum. — *Pseudocidoceras* zonule of the upper Kialagvik Formation.

Age. — Lower to middle *S. sowerbyi* Zone, Bajocian.

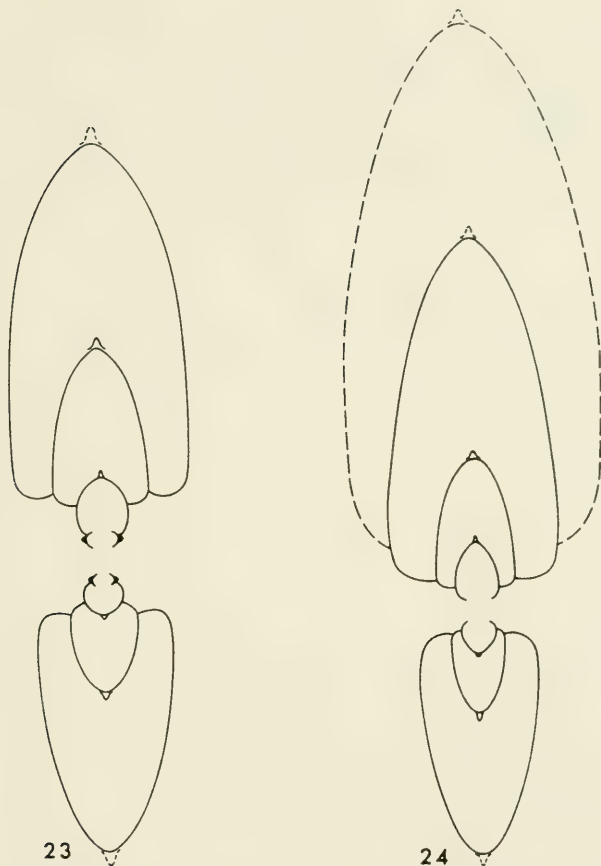
Diagnosis. — A subspecies of *E. klimakomphalum* with sublanceolate whorl section and rounded umbilical margin.

Material. — The holotype and three other incomplete specimens from USGS 12405; two incomplete phragmocones from USGS 19863; one small internal mold from CAS 29011; one large incomplete internal mold from WA 11 at 11m; one fragment from WA 15 at 3 m;? one phragmocone with test remains and one fragment from USGS 21251. All from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation of Wide Bay.



Text-fig. 22.—Scatter with growth lines for relative umbilical width (U:D) of *Eudmetoceras* (*Euaptetoceras*) spp., phragmocones. Note the change from widely umbilicate juvenile whorls to involute mature whorls at 30-40 mm D and the close resemblance between *E. (E.) klimakomphalum* (Vacek) s.s. and *E. (E.) klimakomphalum discoidale*, n. subsp., while *E. (E.) nucleospinosum* Westermann and *E. (E.)* sp. aff. *E. nucleospinosum*, respectively from the *E. howelli* and *S. sawyeri* zones, tend to retain the wide umbilicus.

Description.—The innermost whorls, up to 12-15 mm diameter, are widely umbilicate, subcircular, keeled and may have simple costation with or without fine tubercles. Significantly, the strongest ornament in form of fine tubercles is found in the most widely umbilicate nuclei (paratype, Pl. 14, fig. 8a). There can be little



Text-fig. 23.— Cross-section of *Eudmetoceras* (*Euaptetoceras*) sp. aff. *E. nucleospinosum* Westermann, probably complete phragmocone, loc. USGS 12405 (USNM 160231); $\times 1$.

Text-fig. 24.— Cross-section of *Eudmetoceras* (*Euaptetoceras*) *klimakomphalum discoidale*, n. subsp., phragmocone (section of ultimate half-whorl rotated by 20°), loc. USGS 19863 in the *Pseudocidoceras* zonule (USNM 160230); $\times 1$.

doubt that all specimens from locality USGS 12405 belong to a single variable species.

At 12-15 mm diameter, the whorls become rapidly compressed and involute. The intermediate phragmocone whorls are tightly coiled (U-10-16%), subtrigonal ("lanceolate") in section with nar-



Text-fig. 25. — Septal suture of *Eudmetoceras* (*Euaptetoceras*) *klimakomphalum discoideale*, n. subsp., holotype, phragmocone at 72 mm D; $\times 1.5$.

row, steep and usually well-separated somewhat curved umbilical walls, subparallel inner flanks and gradually converging outer flanks forming (internal mold) an acutely fastigate venter on which is set a high and narrow, hollow-floored keel. The ornament consists of blunt almost rectiradiate, often weakly rursiradiate and somewhat projected costae which in the earlier stages usually reach over the whole flank and are more or less weakly fasciculate. The later growth stages have irregular blunt primaries which split into two or three secondaries; the inner flanks tend to become smooth commencing from the umbilical margin, so that beyond 30-50 mm diameter they bear only irregular radial undulations while the blunt costae are restricted to the outer one-third of the sides.

The last one to one and one-half whorls of the phragmocone, beyond 60-100 mm diameter, are compressed subtrigonal ("lanceolate") in section with well-rounded umbilical slope and narrowly rounded to fastigate venter and strong hollow-floored keel. The broad blunt costation is restricted to the outer third of the whorl sides while the centre and inner flanks are smooth. The end of the phragmocone, which reaches 130-150 mm diameter, may become somewhat wider umbilicate.

The body chamber is preserved only in a few small fragments which show some distant very blunt secondary costation.

The mature septal suture (Pl. 16, fig. 1f; Text-fig. 25) is highly complex with long narrow finger-like lobes. L is longer than E and the U lobes; the L/ U_2 saddle is much smaller than E/L, and the other lobes and saddles of the external suture form a declining sequence with straight saddle-boundary. Only the inner umbilical elements are slightly oblique. However, the suture of the somewhat

more evolute immature whorls (20-35 mm D) is clearly suspensive with two or three oblique umbilical elements.

Discussion. — One large specimen and a fragment from loc. USGS 21251 of the same zonule differ by extremely involute mature whorls and by the preservation of lateral irregular faint spiral markings and strongly projected weak growth lines on the shoulder (Pl. 16, fig. 2; Pl. 18, figs. 1a, b). However, typical spiral striae or grooves as developed in most *Strigoceras* [cf. *S. languidum* (Buckman) described by Imlay (1964, p. B 37) from the *O. sauzei* and *S. humphriesianum* Zones of southeastern Alaska] are absent. The suture is poorly preserved except for some intensely frilled detail. Although this specimen is probably only an involute variant of *E. klimakomphalum discoidale*, the close resemblance to *Strigoceras* is considered significant.

Another specimen of the same assemblage, which is distinguished by evolute nodose juvenile and intermediate whorls, is described below as *E. (Euaptetoceras)* cf. *E. nucleospinosum* Westermann.

Comparison. — This new subspecies is distinguished from *E. klimakomphalum* s.s. by the rounded umbilical slope of the outer whorls and probably also by stronger compressed whorls with more acutely converging flanks forming a more narrowly rounded, almost fastigate venter, and the somewhat wider spaced costation. '*Hammatoceras discus*', Merla and '*Harpoceras (Lioceras) amaltheiforme* mut. *involutum*' Prinz (see Géczy, 1966, p. 80, pl. 20, figs. 1, 3) are both closely affiliated with the restricted species and probably mere varieties. Neither the suture nor the umbilicus of the former appear to be significantly different as supposed by Merla (1934, p. 18) and inferred by Géczy (1966, pp. 65, 66, 80). The distinction of '*H. klimakomphalum paenampectens*' Géczy (1966, p. 81), based solely on the supposedly simpler septal suture of a single possibly corroded specimen, appears dubious. Géczy's statement that *Eudmetoceras amplexens* (Buckman) has a simpler suture than *E. klimakomphalum* does not agree with my own experience and other descriptions (see Westermann, 1964a, pl. 68, fig. 1a; Bremer, 1966, pl. 15, fig. 1a). Elmi (1963, p. 100) is probably correct in placing '*Oppelia subradiata* Sowerby var. *tyrrhenica*'

Renz (1925, pl. 2, figs. 1, 1a) in *E. (Euaptetoceras)*. This species is distinguished from *E. klimakomphalum* s.s. apparently only in the totally smooth inner half of the whorl sides throughout growth. *E. tyrrhenicum* closely resembles '*Oppelia*' *moerickei* Jaworski (1926: lectotype here designated: pl. 3, figs. 12 a-c; ?non fig. 13) from the (upper) *L. concava* or lower *S. sowerbyi* Zone of Mendoza in the southern Andes (type specimens and type locality reinvestigated) which has a hollow-floored keel, a slightly rounded umbilical wall and obsolescent primary costae. *E. klimakomphalum moerickei* is distinguished from *E. klimakomphalum* s.s., *E. k. discoidale* and *E. tyrrhenicum* by the denser, almost rectiradiate and only slightly projected secondaries. The new subspecies has broader, more widely spaced costae than any of the named species and subspecies. There is no sharp umbilical margin or edge as in *E. klimakomphalum* s.s. and the flank of the last whorl rounds gently to the umbilical seam, similar as in *E. amplexens*. '*Witchellia? aguilonia*' Imlay (1964, p. B35, pl. 5) from southeastern Alaska, which is a typical *E. (Euaptetoceras)*, has much more robust whorls with relatively large immature umbilicus and stronger costation.

Measurements. —

	Dmm	W%	H%	U%	P	S
Holotype (phragm.)	88	26.5	—	—	—	32
"	70	27	56	10	(c.10)	28
"	37	28	49	17	—	—
"	24	31	48	21.5	c.12	24
"	13	c.37	42	c.23	—	—
Paratype (body ch.)	56	c.23	53	16	c.15	32
(phragm.)	35	25	41	23.5	c.16	29
"	20	27.5	35	27.5	c.9	—
"	11	35.5	c.33.5	c.28	11 nodes	—
USNM 160230 (phragm.)	c.130	c.25	c.55	c.12	—	—
"	58	26.5	64	13.8	—	31
"	32	—	50	21	—	—
cf. <i>E. klimakomphalum discoidale</i>						
USNM 160232 (body ch.)	80	62	54	7.5 (9)	—	33
(phragm.)	c.67	c.26	c.55	c.9.0	—	—

Eudmetoceras (Euaptetoceras) sp. aff. *E. nucleospinosum* Westermann,
1964 Pl. 17, figs. 2a, b; Text-figs. 22-23

Material. — A single probably complete, slightly damaged,

large phragmocone from USGS 12405 (USNM 160231), upper Kialagvik Formation, probably *Pseudocidoceras* zonule of *S. sowerbyi* Zone, Wide Bay.

Description. — The inner whorls, up to about 40 mm diameter, are widely umbilicate ($U \geq 30\%$) and almost planulate with shallow umbilicus, while the outer one and one-half whorls become abruptly much more involute ($U = 16\%$) and typically discoidal with rounded subvertical umbilical wall.

The nucleus below 12-15 mm diameter is typically "coronate," rounded to somewhat depressed in whorl section with strong lateral nodes [six to seven per half-whorl]. The next whorl is compressed oval in section with fastigate venter on the internal mold; the shell had a sharp hollow-floored keel and carried densely fasciculate, almost rectiradiate, slightly to moderately projected costae which retract from the innermost flanks. The umbilical seam of these inner whorls lies outside the lateral nodes of the preceding whorls at approximately one-half whorl height.

At 45-50 mm diameter, the rounded steep umbilical wall develops and the overlap increases rapidly so that the last whorl's umbilical seam lies on the penultimate whorl's umbilical margin. The inner flanks are now flattened and subparallel while the outer flanks converge gently up to the high, narrow, hollow-floored keel. The last whorl has irregularly branching and somewhat fasciculate, slightly falcid costae which strengthen on the outer flanks; there are about 13-14 blunt prosoradiate primaries and 30-32 projecting secondaries on the last one-half whorl of the phragmocone.

Discussion. — *Eudmetoceras* (*Euaptetoceras*?) *nucleospinosum* Westermann (see appendix) is distinguished by the larger "coronate" stage with somewhat stronger nodes which are "impressed" in the subsequent umbilical wall. *E. amaltheiforme* (Vacek) which is closely affiliated, differs in the cross-section with well-developed shoulders and broadly rounded externside. This specimen is morphologically intermediate between *E. klimakomphalum discoidale* n. subsp. and the slightly older *E. nucleospinosum* from the *E. howelli* Zone of Wide Bay, probably reflecting phylogenetic relationship.

Measurements. —

	Dmm	H%	W%	U%	P	S
USNM 160231 (phragm.)	94	52	25	16	—	30-32
"	43	49	27	c.26	—	—
"	19	38	c.34	32	—	25

Appendix. — *Eudmetoceras nucleospinosum* Westermann, 1964. The measurements of the type specimens were erroneously omitted from the original description (Westermann, 1964a, p. 415, pl. 66) and are given below. Furthermore, it appears now that only the original topotype (U W 16633; *loc. cit.*, figs. 4a-d) which becomes involute at maturity, is conspecific with the incomplete holotype, while the originally designated "paratype" (U W 16635; *loc. cit.*, fig. 5) which remains relatively evolute, is not. *E. nucleospinosum* is, therefore, tentatively transferred from *Eudmetoceras* s.s. to *E. (Euaptetoceras)*. The strongly compressed original "paratype" is probably closely affiliated with *Eudmetoceras (Eudmetoceras) insignoides* (Quenstedt).

Measurements [from plastotypes]. —

	D	H%	W%	U%	P	S
Holotype (phragm.)	c.37	c.53 (19.5mm)	c.38 (14mm)	c.32	—	c.25
"	24	38	38	33.5	(c. 9)	—
"	12	33	58	29	6 spines	—
UW 16633 (phragm.)	(60-65)	—	(16 mm)	c.16 (10mm)	—	—
	28	43	c.34	29	—	—
	19	45	42	31.5	—	—
	12	35	c.55	37.5	5.5 spines	—
[sp. nov. ?]						
UW 16635 (phragm.)	79	44	c.19	26	—	32
	59	43	—	28	c.15	31

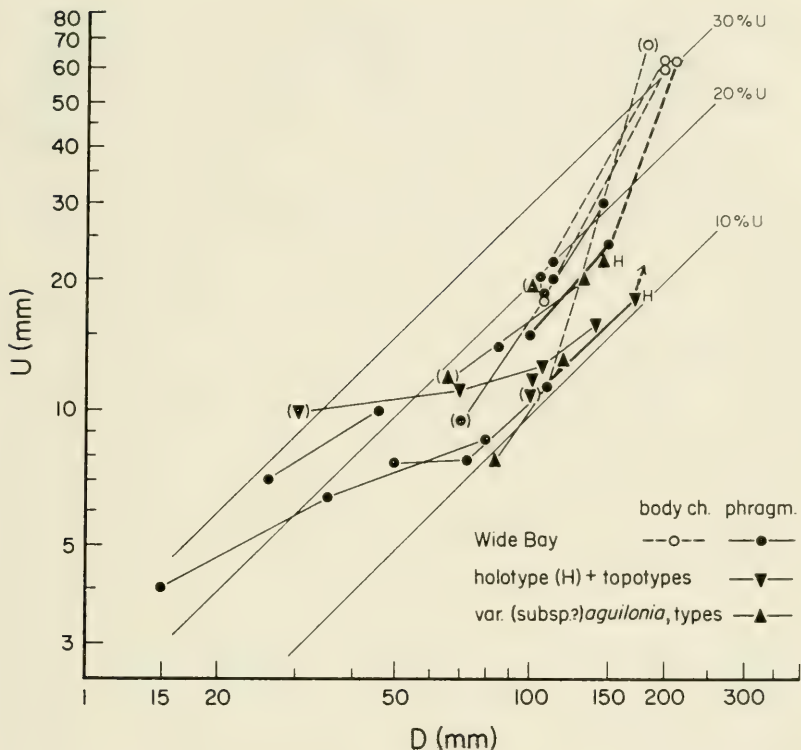
***Eudmetoceras (Euaptetoceras) amplexens* (Buckman) 1889 [?forma or subsp. *aguilonia* (Imlay) 1964]** Pls. 19-21; Text-fig. 26

1889. *Hammatoceras amplexens*, sp. nov., Buckman (Dorset), Quart. Jour. Geol. Soc., vol. 45, p. 662.

1920. *Eudmetoceras amplexens* (Buckman), Buckman (Dorset), Type *Ammonites*, III, pl. 180A, pl. 180 B, figs. 1 (holotype), 2.

?1940. *Hammatoceras* sp., Althof (Germany), Palaeontogr., vol. 85, B, p. 38.

1957. *Eudmetoceras amplexens* (Buckman), Lieb (Swiss Jura), Ber. schweiz. palaeont. Ges., vol. 50, p. 580 [specimens seen].



Text-fig. 26.— Scatter with growth lines for relative umbilical width (U:D) of *Eudmetoceras (Euaptetoceras) amplexens* (Buckman), for comparison of the type specimens from England with the sample from the *E. amplexens* zonule of Wide Bay and '*Witchellia? aguilonia*' Imlay [= var./susp.? of *E. amplexens*] from the *O. sauzei* Zone of southern Alaska. Note the morphogenetic change and the great similarity of the three "samples" with the possible exception of adult phragmocones; however, the holotype of *E. amplexens* is probably an involute variant.

1963. *Euaptetoceras amplexens* (Buckman), Elmi (S.E. France), Trav. Labor. Géol. Lyon, p. 72, pl. 10, figs. 1a, b.
 1964. *Eudmetoceras amplexens* Buckman, Sapunov (Bulgaria), Trav. Géol. Bulg., sér. Paleont., vol. 6, p. 261, pl. 1, figs. 1a, b, pl. 3, figs. 1a, b.
 1964. *Eudmetoceras amplexens* (Buckman), 1886 [error for 1889], Westermann (Wide Bay), Bull. Amer. Paleont., vol. 47, No. 216, p. 417, pl. 67, figs. 2a-c; pl. 68, figs. 1a-c; text-figs. 28, 29.
 1964. *Witchellia? aguilonia* Imlay n. sp., Imlay (Alaska), U.S. Geol. Sur., Prof. Pap. 418-B, p. B35, pl. 4, fig. 9, pl. 5, figs. 4, 7-9.
 (?) 1964. *Witchellia? aff. W.? aguilonia* Imlay n. sp., Imlay, *id. ac.*, p. B36, pl. 4, figs. 1-4.

1966. *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buckman), Bremer (Turkey), N. Jb. Geol. Palaeont., Abh. 125, p. 159, pl. 15, fig. 1.
- (?) 1966. *Hammatoceras* (*Pseudaptetoceras*) *klimakomphalum involutum* (Prinz, 1904), Géczy (Hungary), Geol. Hung., sér. Paléont., fasc. 34, p. 80, pl. 20, figs. 1, 3.
- non 1955. *Eudmetoceras amplectens* (Buckman), Maubeuge (Swiss Jura), Mém. suisse paléont., vol. 71, p. 34, pl. 6, figs. 4, 5, [= *E. cf. klimakomphalum* (Vacek)].
- non 1966. *Eudmetoceras* (*Euaptetoceras*) *amplectens* Buckman, Blaison et al. (French Jura), Bull. Soc. Hist. Nat. Doubs, No. 68, fasc. 4, p. 100, figs. 1, 2 on p. 101 [= *E. cf. amaltheiforme* (Vacek)].

Material. — Nine incomplete and more or less strongly corroded internal molds, partly with body chambers and test remains, and several fragments, from WA 8 (J 952-968); ? one fragment from WA 4; two fragments from WA 5; two internal molds of phragmocones and body chamber fragments from WA 12 (J1262a, b); one almost complete well-preserved phragmocone from USGS 12405. The collections WA 4, WA 5 and WA 8 are from the massive greywacke beds [*E. amplectens* zonule] at the base of the *S. sowerbyi* Zone; USGS 12405 is from the superjacent *Pseudocidoceras* zonule of the same zone, while WA 12 is from the *Pseudobigotites* zonule of the *O. sauzei* Zone. All from the Kialagvik Formation, southeast shore of Wide Bay.

Description. — This material appears to belong to a single species which is highly variable in coiling (umbilical width), both morphogenetically and infraspecifically (Text-fig. 26). As usual, the more loosely coiled forms are more strongly ornate than the very involute forms. Because the involute variants are indistinguishable from typical *E. amplectens* (Pls. 20, 21; Text-fig. 26) the whole material is placed in this species. The abundant relatively evolute forms ($U \geq 15\%$) may be distinguished as 'forma aguilonia' (Imlay). It is, however, improbable that these constitute an independent subspecies or species. Both formas are present in the basal *S. sowerbyi* Zone and in the *O. sauzei* Zone, but the more widely umbilicate forms may be relatively more frequent above, at Wide Bay and on the Iniskan Peninsula. Alternately, the total intergrading form group could perhaps be included in the subspecies *E. amplectens aguilonia* (Imlay).

The mature shell is large, involute and subdiscoidal with rounded umbilical slope, broadly rounded venter carrying a hollow-floored keel, obsolescent primaries and densely spaced moderately projected secondaries. The umbilical seam of the last whorl, including the body chamber, egresses strongly. The nucleus is much more widely umbilicate than the mature phragmocone and may have very blunt, irregular, distantly spaced primaries. The morphogenesis from this evolute juvenile stage into the typical involute growth stage occurs at varying sizes; as expected, a longer retained and more evolute juvenile stage will generally result in a less involute mature shell, *i.e.* forma *aguilonia* (Text-fig. 26).

The nucleus is visible in two specimens (J 965 and USNM 160234; Pl. 21, fig. 1d). The innermost whorls are subcircular bearing a low sharp keel and moderately evolute (27% at 15 mm D) becoming slightly compressed oval at 12-15 mm diameter, and embracing the preceding whorl slightly more than one half. At 20-25 mm diameter the whorls become abruptly more involute and develop a compressed trapezoidal whorl section with rounded umbilical walls and shoulders. The mature phragmocone of the complete specimen is narrowly umbilicate (11%), discoidal with well-rounded umbilical margin and steep but not vertical umbilical slope, converging outer two-thirds of the flanks and broadly rounded venter which carries a hollow-floored keel. There are only some irregular swellings on the inner flanks of the penultimate halfwhorl while the outer third of the flank carries blunt, moderately projected secondaries, 31 per halfwhorl. The other nucleus (J 965) is from a more widely umbilicate specimen. The whorl section changes from subcircular to compressed oval at 15 mm diameter, becomes trapezoidal at 20-25 mm D, but remains relatively evolute (27% at 26.5 mm D, c. 26% at 32 mm D, 22% at 46 mm D). This specimen has much stronger costae which on the nucleus are irregularly fasciculate and markedly falcoid with raised, irregularly arranged bullae-like swellings on the inner flanks. At about 30-35 mm D the costae become rectiradiate, moderately projected and restricted to the outer flanks while the inner flanks have only a few irregular broad swellings. There are about 26-30 secondaries per halfwhorl. This form is probably identical with

'*Witchellia*? aff. *W.?* *aguilonia*' of Imlay (1964, pl. 4, figs. 1-4) from the *O. sauzei* Zone of the Iniskin Peninsula.

Other specimens from the fossiliferous *E. amplexens* zonule (WA 8) are intermediate in all visible morphological features between the involute weakly ornate forms (J 963) and the more widely umbilicate, more strongly ornate forms (J 968). Irregular broad swellings on the inner flanks which often extend onto the umbilical slope, can be seen in the umbilici of most median to relatively widely evolute variants. One of the evolute variants (J 968) has distant blunt primaries (about five per halfwhorl) up to a diameter of 110 mm. The secondaries on the mature phragmocone of these relatively evolute variants are widely spaced (about 25 per halfwhorl) and weaken markedly only towards the end of large phragmocones at 120-150 mm diameter, while the costation of the involute variants (averaging 30 secondaries per halfwhorl) becomes obsolete already at 80-110 mm. Densely spaced, slightly concave simple growth lines are sometimes visible even on the internal mold and some low swellings may be developed.

Toward the end of the phragmocone, at about 80-100 mm diameter, the umbilical seam egresses rapidly, the umbilical wall becoming lower and less steep. The full phragmocone diameter is 120-160 mm.

The body chamber is two-thirds to three-fourths whorls long; the two specimens with preserved apertures are approximately 200 mm in diameter. The umbilical seam egresses strongly until the aperture embraces only about one-third of the preceding whorl. While the whorl height is somewhat reduced, the inner height (dorsum to venter) remains approximately constant. The flanks flatten and may become slightly concave in the lower third. The aperture is preceded by a weak constriction of the internal mold probably indicating thickening of the shell. The peristome is sigmoid with broad mid-lateral projections and ventral lappet (Pl. 21, fig. 2).

The septal suture is highly complex with slender endings which interfinger from one line into the next. L is longer than E; the saddles decrease successively in size towards the umbilical seam following a straight saddle line; the inner umbilical elements ($U_3 + ?$) are usually oblique and somewhat suspensive.

Discussion. — Since the first volume of this monograph (Westermann, 1964a) went into press, *Eudmetoceras amplexens* has been described (1) from the Mâconnais in eastern France (Elmi, 1963), (2) from beds between the *L. concava* and *S. sowerbyi* 'beds' [? *L. discites* Subzone] of Bulgaria (Sapunov, 1964), (3) possibly from the *L. concava* Zone of Hungary (Géczy, 1966; as *Hammato-ceras klimakomphalum involutum* (Prinz)), (4) from the *L. discites* Subzone of Turkey (Bremer, 1966), and (5) from the *O. sauzei* Zone of southern Alaska (Imlay, 1964; as *Witchellia? aguilonia*, n. sp.).

While the European and Turkish finds, as well as the two specimens described in my first volume from the *E. howelli* Zone of southern Alaska lie within the generally accepted vertical range of *E. amplexens*, i.e. (upper) *L. concava* to lower *S. sowerbyi* Zones, the range of the species is now extended into the *O. sauzei* Zone for Wide Bay and probably also for the Talkeetna Mountains of the Iniskin Peninsula (type locality of '*W.? aguilonia*'), southern Alaska. Although the exact level of the Talkeetna Mountains occurrence is unknown and the zonal assignment, therefore, tentative, the *S. sauzei* Zone is well established for the Wide Bay specimens. I have seen the specimens from Wide Bay recorded by Imlay (as *Witchellia? aguilonia*) and recovered one each of the involute and the more widely umbilicate forms from the *Pseudobigotites* zonule of locality WA 12, more than 100 m above the *Pseudocidoceras* zonule. '*Witchellia? aff. W.? aguilonia*' Imlay (1964 p. B36) appears indeed to be an evolute variant of '*W.? aguilonia*' with which it is associated also in the Talkneeta Mountains.

Imlay (1964, p. B36) noted the "similar appearance" of the '*Witchellia? aguilonia*, n. sp.' and *Eudmetoceras amplexens* but was obviously averted by the slight difference in age. He also stated that the former "appears to have more flexuous less regular ribbing that tends to be more fasciculate." However, these supposed differences do not apply for the majority of specimens, including both figured specimens of '*W.? aguilonia*' [holotype and paratype], according to my knowledge of *E. amplexens* topotypes.

On the strength of the septal suture as figured by Imlay (1964, pl. 5, fig. 4) from a paratype, as partly seen on the photograph of the holotype, and observed by me on other specimens

including 'W.? aff. W.? *aguilonia*' of Imlay (1964, pl. 4, fig. 4), there can be no doubt that '*Witchellia?* *aguilonia*' belongs to the Hammatoceratinae and not to the Sonniniidae. The suture is extremely complex, and the umbilical elements are suspensive.

The majority of the southern Alaskan specimens are distinguished from typical European *E. amplexens* in the somewhat wider umbilicus of the (mature) phragmocone ($U=15-20\%$ vs. $10-12.5\%$) and by the often present widely spaced, strongly irregular swellings on the inner flanks of the inner whorls. However, these swellings are apparently absent on the holotype and the large figured paratype of 'W.? *aguilonia*'. Furthermore, the morphological variation of the typical European *E. amplexens* is poorly known. It is possible that *E. amplexens* of Dorset (type locality) intergrades with the more widely umbilicate *E. amaltheiforme* [syn. *E. euaptetum* Buckman] which has densely spaced primaries. Although the European *E. amplexens*, including the holotype, reach the involute growth stage at a small size, some specimens, such as Buckman's paratype (pl. 180, B, fig. 2), retain the more widely umbilicate stage until about one-half full size ($U=16.5\%$ at 69 mm D, see Text-fig. 26). The fact that no European *E. amplexens* has been described with a mature umbilical width of more than 13% , as is common in the Alaskan forms of both *S. sowerbyi* and *O. sauzei* zones, may be due to "splitting" although this appears improbable.

In conclusion, it is advisable to place the more evolute ornate and the involute weakly costate specimens from Alaska in the single species *E. amplexens* and, if necessary, to distinguish the former as forma *aguilonia* rather than as subspecies *aguilonia*.

The involute forms of the Alaskan *E. amplexens* resemble *E. klimakomphalum discoidale* n. subsp. from the slightly younger *Pseudocidoceras* zonule of Wide Bay from which they are distinguished particularly in the broad shoulders. Significantly, these species have never been found together which is probably owing to different habitats, i.e. *E. amplexens* possibly living in shallower water.

Measurements. —

	Dmm	W%	H%	U%	P	S
USNM 160234 (phragm.)	78	33	54	11	—	31
" "	35	38.5	59	18		
" "	15	42	45	27	—	—
McM J965 (phragm.)	46	35	52	22	(swellings)	c.28
	26.5	20	46	27	4+6 fasc.	21
McM J968 (aperture)	c.210	c.17 (36mm)	c.33	c.29 (62mm)	—	—
(phragm.)	150	20	47	16	—	c.28
	c.100	—	c.50 (50mm)	c.15 (15mm)	5	c.26
McM J963 (aperture)	c.185	c.17 (31mm)	c.32	c.37 (68mm)	—	—
(phragm.)	108	26	51	10.5	—	—
	73	29	53	10.5	—	—
	50	32	55	15	—	30-32
McM J960 (body ch.)	200	c.39	c.16	c.30	—	—
" (phragm.)	107	c.24	c.50	c.18.5	—	(obsol.)
McM J956 (phragm.)	14	—	49	19	—	c.36
" "	c.85	—	c.51	c.16.5	--	—
McM J953 (body ch.)	107	24	50	16.5	—	—
(phragm.)	70	—	48.5	c.13.5	—	—
McM J952 (phragm.)	145	22	42	21	—	—
" "	107	2	2	17	—	—
<i>O. sauzei</i> Zone:						
' <i>Witchellia?</i> <i>aguilonia</i> ', paratype [from plaster cast]						
(phragm.)	132	25	50	15	—	37
" "	c.65	c.31 (20mm)	c.49 (32 mm)	c.18 (12mm)	—	—
Holotype [from plaster cast]						
(end phragm.)	145	23	50	15	—	47
' <i>W.</i> ? <i>aff. W.</i> ? <i>aguilonia</i> ' USNM 13157 [from fig.]						
(phragm.)	75	—	49	22.5	7	—
" "	55	—	42	30	6	26
J1262a (end phragm.)	117	23	50	11.5	—	40
" "	84	30	53	9.5	—	—
J1262b (phragm.)	100	29 (29mm)	52 (52mm)	20	—	—

cf. **Eudmetoceras** s. l. indet. [? ♂]

Pl. 21, fig. 3

Material. — A single right external mold from WA 8, lower part (McM J 958). *E. amplexens* zonule of the *S. sowerbyi* Zone, upper Kialagvik Formation, Wide Bay.

Description. — At 36 mm diameter, the whorls are compressed oval in section and widely umbilicate (33%). Significantly, the umbilical seam egresses markedly at the end of the preserved conch which coincides with modification of the costation, suggesting that the shell was adult. However, the septation is invisible.

The costation consists of somewhat falcoid costae forming bullae where they fasciculate, and of intercalatories. On the last one-quarter whorl, the costae become partly reduced and irregularly spaced.

Discussion. — This probably adult and complete specimen closely resembles the nucleus (up to c. 25 mm D) of the widely umbilicate variant of the macroconchiate *Eudmetoceras amplexens* and could, therefore, be the corresponding microconch (male). The microconchiate subgenus *E. (Rhodanicerias)* Elmi is distinguished by ventral sulci and strong, not projected costae.

Genus **PLANAMMATOCERAS** Buckman, 1922

?Subgenus **P. (PSEUDAMMATOCERAS)** Elmi, 1963

[“*Parammatoceras*” Buckman, 1925, *nom dub.*]

Planammatoceras (Pseudammatoceras?) cf. **P. benneri** (Hoffman) 1913
Pl. 22, figs. 2, b

(?) 1913. *Hammatoceras benneri* sp. nov., G. Hoffmann (Germany), Strat. u. Amm. Fauna Unt. Doggers in Sehnde, p. 191, pl. 18, fig. 15.

1964. *Sonninia* cf. *S. patella* (Waagen), Imlay (Cook Inlet), U.S. Geol. Sur., Prof. Paper 418-B, p. B33, pl. 4, figs. 2-4.

Material. — One large almost complete well-preserved specimen from USGS 21251 (USNM 160235). *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The inner whorls up to 25-30 mm diameter are widely umbilicate, subcircular in section, and have a thin low keel. Subsequently, the whorls become more involute and increasingly compressed with subtriangular section and narrowly rounded venter with hollow-floored, low keel. The narrow steep umbilical wall becomes increasingly more separated from the slightly convex and converging flanks by the umbilical margin.

The costation of the nucleus (20 mm D) consists of slightly rursiradiate and weakly projected simple ribs which partly fasciculate. Subsequently, widely and irregularly spaced (4-6/halfwhorl) strong bullae-like primaries develop on the inner third of the flanks while the intermediate primaries become obsolete. The secondaries, about four times as numerous as the primaries (20/halfwhorl), are blunt slightly rursiradiate and somewhat projected on the shoulders. They die out gradually beside the keel. The middle of the flank, at the base of the secondaries and beneath the subsequent umbilical seam, is almost smooth so that the secondaries appear disconnected. Towards the end of the phragmocone (120 mm D), the costae become obsolete with some wide undulations remaining on the inner flank.

The body chamber, three-fourths whorls long, terminates in the partly preserved simple aperture (195 mm D). The inner flank becomes more compressed and slightly concave beside the well-developed umbilical margin. The outer three-fifths of the flanks are flat and converge to the broadly rounded shoulders. The venter is obtusely fastigate. The last halfwhorl is smooth except for faint somewhat prosoradiate and slightly projected growth lines.

The septal suture is highly complex with typically oblique and suspensive umbilical lobes.

Discussion. — The specimen closely resembles *Sonninia* ex. gr. *S. patella* (Waagen) for which it was at first mistaken before the typically hammatoceratid septal suture was observed.

This specimen belongs to the species-group of '*Hammatoceras*' *sieboldi* (Oppel) which flourished in the *L. munchisonae* Zone and was placed in the dubious '*Parammatoceras*' Buckman by Elmi (1963, p. 65; holotype refigured). The Wide Bay form is distinguished from '*H.*' *sieboldi* by the much wider spaced secondaries and closely resembles '*H.*' *benneri* Hoffmann, originally described from the upper *L. concava* Zone (+ *L. discites* Subzone) of Hannover, Germany. Elmi (1963, p. 94) placed '*H.*' *benneri* in *Pseudamatoceras* but separated Hoffmann's similar paratype (fig. 14) not only specifically (using the species name *achillei* which had been tentatively suggested by Hoffmann) but generically by placing it in *Eudmetoceras* s.s.

Of special significance is the occurrence of this form in the Talkeetna Mountains on the Iniskin Peninsula of southeastern Alaska. The single large specimen described as '*Sonninia* cf. *S. patella* (Waagen)' by Inlay (1964, p. B33, pl. 4, figs. 2-4) came from a large collection indicating the *O. sauzei* Zone (*op. cit.*, table 12, p. B27); although it might have originated in a lower horizon within the 60-65 thick sequence of USGS locality 324113 (*op. cit.*, table 11). My reinvestigation of this specimen (May 1967) showed that the septal suture is complex and strongly suspensive in contrast to the development in all Sonniniidae. If the origin of this form in the *O. sauzei* Zone can be established, the upper range of the Hammatoceratinae would be extended from the (lower) *S. sowerbyi* Zone to the *O. sauzei* Zone.

Measurements. —

	Dmm	H%	W%	U%	P	S
USNM 160235 (body ch.)	195	—	—	—	—	—
"	165	39.5	22	31	—	—
(phragm.)	120	43	27.5	28	8	c.30
"	63	45.5	38	32	6-7	c.25
"	29	36	37	38	5-6	—

Family **SONNINIIDAE** Buckman, 1892

Genus **SONNINIA** Bayle, 1879

Subgenus **S. (EUHOPLOCERAS)** Buckman, 1913

[Syns. *Sherbornites*, (?) *Stiphromorphites* Buckman, 1923]

Type species. — *Sonninia acanthodes* Buckman, 1889 (1892) [= *S. adicra* Waagen, 1876]. — The originally figured early juvenile stage by Buckman in 1889 (p. 658) cannot be regarded as, and was not meant to be, the holotype. The detailed description of the species and the first figures of mature specimens were given by the same author in 1892 (plate 58 and later) who depicted the large almost complete specimen on plate 60 as 'type-specimen'. The same figure was reproduced in the Treatise (Arkell, *et al.*, 1957, p. L 269). The specific identity of probably all 65 larger *Euhoploceras* 'species' of Buckman from the *L. discites* Subzone of Bradford Abbas in Dorset, as well as of about a dozen central European 'species' and 'subspecies,' with *Sonninia adicra* Waagen has recently been established (Westermann, 1966). It appears that only

the single highly variable species *S. adicra* can clearly be distinguished within the European realm of the subgenus *S. (Euhoploceras)* which ranges laterally from southern England to Morocco but is vertically essentially restricted to the *L. discites* Subzone, although appearing rarely in the *L. concava* Zone of southern England and ranging into the *S. trigonalis* Subzone of the middle *S. sowerbyi* Zone.

The distinction of *Sonninia (Euhoploceras)* from *Sonninia s.s.* is certainly not sharp. Even the type species of the latter, *S. propeinquans* Bayle, resembles *S. adicra*, type species of the former, in many respects; several intermediate forms have been named such as *S. spinifera* Buckman and *S. sowerbyi adicroides* Hiltermann, both of which are now placed in *S. adicra*. Nevertheless, the subgenus has been retained in the Treatise and most recently by Westermann (1966) especially because of stratigraphic usefulness. *S. (Euhoploceras)* includes *Sonniniidae* tending to have evolute rounded whorls with rursiradiate strong costae, which are retained beyond the spinous stage onto the body chamber, and a thin low hollow-floored keel. However, some variants become almost or entirely smooth with compressed whorls and no single character is diagnostic for this subgenus.

In the circum-Pacific realm, *S. (Euhoploceras)* is known from northern California, Oregon, (?) Alberta, southern Alaska (here described) and Western Australia. The *S. sowerbyi* Zone is more or less strongly indicated at all occurrences.

At Mount Jura in Shasta County, California, '*Stiphromorphites schucherti*' Crickmay (1933, pl. 28, *nom. dub.*), a probable but poorly known *S. (Euhoploceras)*, occurs in the Mormon Formation below beds with *S. (Papilliceras)* spp. of the *O. sauzei* Zone and well below *Normannites (Itinsaites)*.

The best published sequence is in the Supplee area of east-central Oregon (Lupher, 1941), but the abundant new forms have not yet been described. The author visited and recollected the principle section in 1962. The Weberg Formation of the Colpitts Group contains a fauna of large *S. (Euhoploceras)* with typically straight strong costae on the outer whorls, evolute *Witchellia* ('*Zugophorites*'), early cf. *Strigoceras* [or? *Praestrigites*], cf. *Docidoceras s.l.*,

Eudmetoceras?, and abundant pelecypods. *Tmetoceras* occurs beneath and stephanoceratids several hundred meters above.

From an isolated exposure of the Fernie Group at Lake Minnewanka near Banff, Alberta, several poorly preserved (?) *S. (Euhoploceras)*, which are probably conspecific with the Wide Bay form, were described and tentatively compared with *Sonninia gracilis* Whiteaves by Frebold (1957a, p. 48, 49, pl. 20). They are probably also associated with *Witchellia* ('*Zugophorites*') (*op. cit.*, pl. 19, fig. 2).

Another poorly known *S. (Euhoploceras)* is '*S. playfordi*' Arkell (1954, pl. 27; *nom. dub.*) from the Newmarracarra Limestone of Western Australia which was figured in the side view of a single fragment. However, the material did not justify the naming of a new species and the specific characters remain dubious. The Australian *S. (Euhoploceras)* is associated with *Pseudotoites*, as at Wide Bay, an involute *Witchellia* and abundant *Fontannesia*, and therefore belongs in the *S. sowerbyi* Zone.

Sonninia (Euhoploceras) closely resembles and is directly ancestral to *S. (Papilliceras)* which has similar almost world-wide distribution and indicates the *O. sauzei* Zone, although in Europe it may appear already in the upper *S. sowerbyi* Zone. *S. (Papilliceras)* is characterized by the reduction of costae, the retention or mature re-appearance of medio-lateral spines or nodes, and the strongly compressed whorl section. However, the delimitation from *S. (Euhoploceras)* has to be based on several characters such as whorl section, umbilical width and ornamentation; where both subgenera overlap in whorl section, *S. (Papilliceras)* is distinguished by more evolute whorls and somewhat stronger ornamentation (Westermann, 1966, text-fig. 6.)

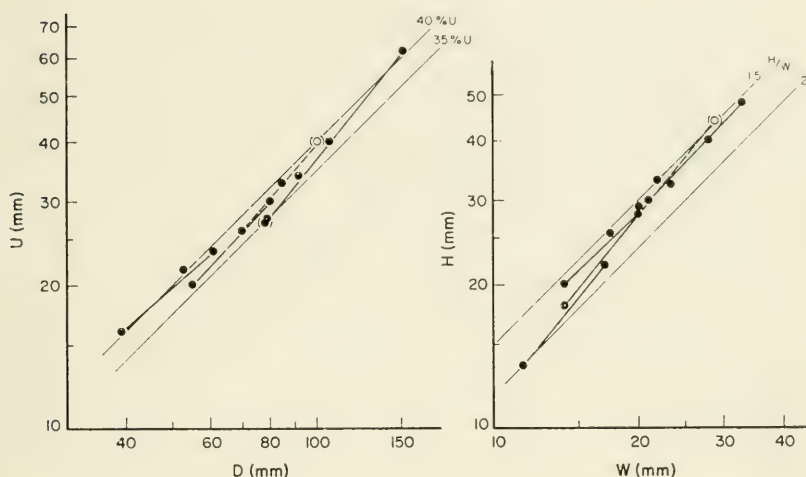
***Sonninia (Euhoploceras) bifurcata* Westermann, n. sp.**

Pls. 23-26;
Text-figs. 27-31

(?) 1957. *Sonninia* sp. indet., Frebold (Alberta), Geol. Sur. Canada, Mem. 287, p. 48-49, pl. 20, figs. 1-3 [plastercasts studied].

1965. *Sonninia*? n. sp. indet., Imlay (Cook Inlet), U.S. Geol. Sur., Prof. Paper 418-B, p. B33, pl. 4, figs. 5, 6, 10-12 [specimens studied].

Holotype. — Pl. 23, figs. 1a, b; Text-fig. 30a. Internal mold of phragmocone with one-third whorl of incomplete and deformed body chamber. Repository: USNM 160236.



Text-fig. 27. — Scatter and growth lines for relative umbilical width (U:D) and whorl section (H:W) of *Sonninia (Euhoploceras) bifurcata*, n. sp., from the (lower) *S. sowerbyi* Zone of Wide Bay; dots and solid lines for phragmocones, circles and dashed lines for body chambers. Note the slightly larger umbilical width of the mature whorls (60-80 mm D).

Locus typicus. — U.S. Geol. Survey Mesozoic locality 12405, south shore of Wide Bay, Alaska Peninsula.

Stratum typicum. — Shales of upper Kialagvik Formation.

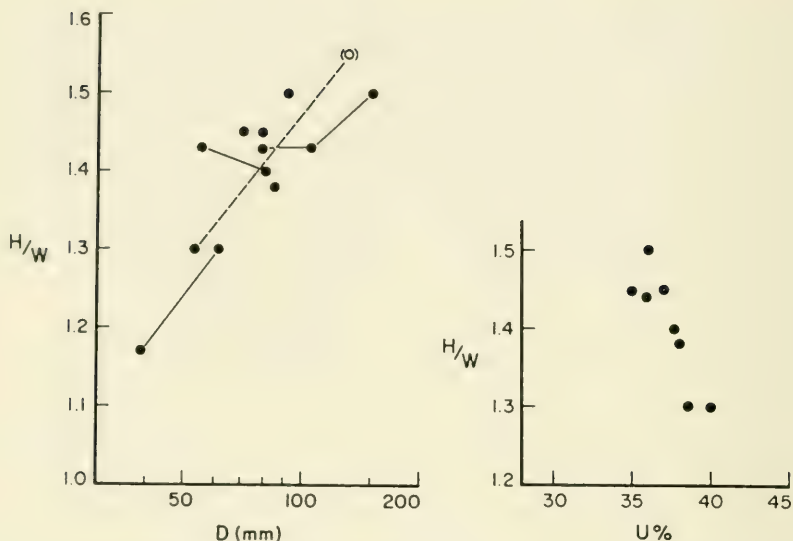
Age. — *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Bajocian.

Other occurrences. — *O. sauzei* Zone of the Cook Inlet region; (?) *S. sowerbyi* Zone of Devils Point at Lake Minnewanka in Alberta; (?) *S. sowerbyi* Zone near Supplee in Oregon.

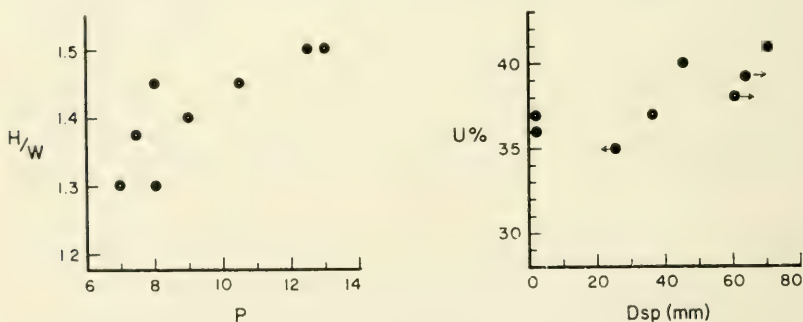
Derivatio nominis. — The costae bifurcate commonly on the inner whorls.

Diagnosis. — Large, whorls more or less compressed oval to subrectangular; phragmocone moderately to strongly evolute with lateral bullae and irregularly bifurcating ribs or with irregularly fasciculate ribs, robust on shoulders; body chamber with few strong rectiradiate or somewhat curved simple and bifurcating ribs; simple straight ribs on large body chambers.

Material. — Holotype, two phragmocones with incomplete body chamber, four incomplete phragmocones and one fragment from



Text-fig. 28.—Scatters and growth lines for whorl sections of *Sonninia* (*Euhoploceras*) *bifurcata*, n. sp. (for explanation of symbols see Text-fig. 27). The whorls tend to grow continuously more compressed, although this is not necessarily so in every specimen. Right: 'compression' (H/W) of mature phragmocone whorls (53-92 mm D) is inversely correlated with relative umbilical width; this is due to "partial logical correlation" since increasing whorl overlap narrows the umbilicus but increases whorl height.



Text-fig. 29.—Scatters for "ornament" vs. shell shape of *Sonninia* (*Euhoploceras*) *bifurcata*, n. sp. Left: 'compression' (H/W) of the adult phragmocone is positively correlated with density of primaries (P , number per half-whorl), i.e., the more compressed whorls have weaker primaries and vice versa. Right: Relative umbilical width of the adult phragmocone ($U:D \times 100 = U\%$) appears to be weakly correlated with the diameter of the spinose growth stage (Dsp), i.e., the more evolute whorls tend to be somewhat more 'ornate' (arrows indicating correction of possible error).

USGS 12405 (USNM 160238, 160239, 160241); two phragmocones with incomplete body chambers and two fragments from USGS 19869 (USNM 160240, 160242); several fragments from USGS 19862 and 19870; three moderately preserved specimens from 1-6 m (McM. J 981), one small nucleus from about 16 m (McM. J 990) and one almost complete internal mold from scree (McM. J 975) of WA 10; 12 mostly incomplete or fragmental specimens and several body chamber fragments from WA 13w; four partly deformed fragments from 3 m, 10 m and 17 m of WA 15.

Description.—The nucleus is incompletely known and only visible laterally in the umbilicus of a spinose specimen (McM. J 990). Lateral costae are already present at about three mm diameter consisting of irregularly strong fasciculate primaries. Strong bullae-like lateral spines, seven to eight per halfwhorl, are developed at about 16 mm diameter.

The few preserved juvenile stages (10-20 mm) have somewhat depressed oval whorls with narrow and low sharp keel which, at least in the internal mold, is accompanied by narrow sulci. The ornament consists of strong blunt bifurcating costae which extend in full strength up to the sulci, and usually of heavy somewhat bullae-like lateral spines.

The adolescent whorls range from subcircular to moderately compressed oval ($H/W = 1.1 - 1.5$) and from moderately to widely evolute ($U = 30-40\%$). The sulci are usually retained except for the compressed weakly ornate variants. The spinose variants possess few strong lateral spines on high primaries and usually have some weak blunt intercalated primaries without spines. The major primaries bifurcate or trifurcate at about three-fifths whorl height and some secondaries are intercalated. All secondaries project somewhat and retain their full strength or swell to form weak bullae on the shoulders; they are abruptly truncated at the sulci. The spinose stage, if present, may be retained to almost the end of the phragmocone. More commonly, at 25-50 mm diameter, the spines become bullae. With further growth, spines or bullae finally weaken and may become obsolete. The nonspinose variants bear blunt bullae often arising from simple fasciculation, and irregular much weaker intercalated ribs; other specimens have only weak ribs with a few stronger ones irregularly intercalated.

The last whorl of the phragmocone (80-150 mm D) and the body chamber (120-250 mm D) are moderately compressed elliptical to ovate (H/W 1.4 - 1.5) and evolute ($U = 36.41\%$). The body chamber egresses markedly only in the more involute forms resulting in similar body chambers with about 40% umbilical width. The externside of large phragmocones is rounded, often flattened, and carries a moderately high narrow keel. Rarely developed shallow sulci are probably restricted to the internal mold.

The stronger primaries and lateral bullae of the body chamber or the lateral bullae become more regular and continue into one of the secondaries, usually the posterior one, resulting in single long somewhat curved ribs. The remaining weaker secondaries are retained for some time. On most body chambers and also on some large phragmocones, the single long ribs strengthen and become more or less rectiradiate, rarely typically rursiradiate, and somewhat projected on the shoulders, while the secondaries fade. The thin keel is retained. The adult stage almost perfectly resembles *S. (Euhoploceras) adicra* (Waagen).

As usual in larger Sonniniidae (♀), apertures are not preserved; adulthood is indicated only by several specimens with approximated last two to three septal sutures at 85-140 mm diameter.

The septal suture is of moderate complexity and nonsuspensive. The saddle boundary may even be slightly reclined ventrally. The saddles decrease gradually in size; the lobes are slender trifid.

Discussion. — There is no doubt that all *S. (Euhoploceras)* from Wide Bay form a single morphological series, their duration was limited, and that they, therefore, belonged to a single palaeo-species. This is evident in the few larger samples from localities USGS 12405 and WA 13w. The latter outcrop includes only a few meters of the total vertical range of 30-50 m. No evolutionary trend is apparent throughout the range; however, the compilation of the section is admittedly inaccurate.

Of interest within this supposed single palaeo-species is the morphologic inter-relation (co-variation) of evolute round whorls with strong spinose costae, and of more involute compressed whorls with fine weak ornament (Text-fig. 29). This is in full accordance with the "(1st) Buckman Law of Co-variation" (Westermann,

1966) which was first described from the closely related *S. (Euhoploceras) adicra* Waagen and which applies to the great majority, if not to all, known species of ornate ammonites.

Comparison. — Two incomplete specimens of this species were recently described as '*Sonninia?* n. sp. indet.' by Imlay (1964, p. B33, pl. 4, figs. 5, 6, 10-12), respectively from the Tuxedni Formation in the Talkeetna Mountains and from the Red Glacier Formation on the Iniskin Peninsula, both in the Cook Inlet region of southeastern Alaska. Significantly, the former occurrence belongs possibly and the latter probably in the *O. sauzei* Zone.

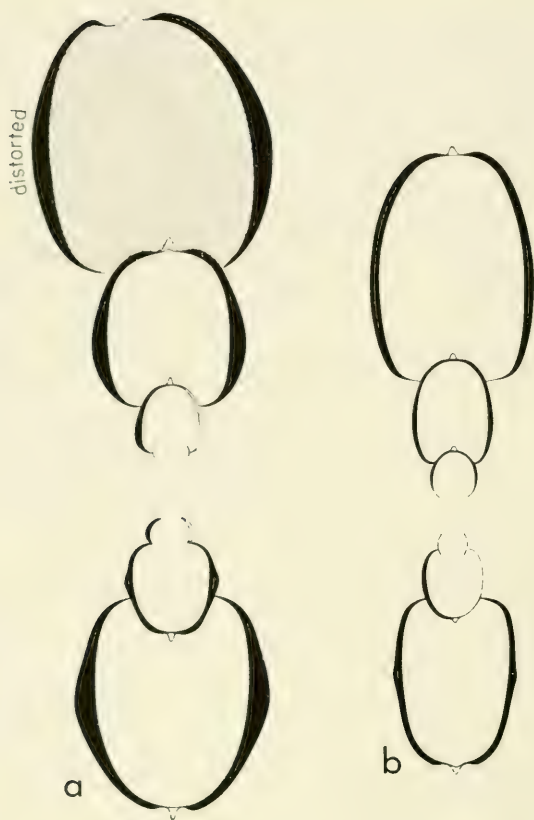
Probably identical with this species or closely affiliated are the three poorly preserved specimens from Devils Point at Lake Minnewanka, Alberta, which were briefly described and figured by Frebold (1957a, pl. 20, figs. 1-3) as *Sonninia* sp. indet. Although only 80-90 mm in diameter and probably incomplete or immature, they show a similar variety of ornament and apparently also of coiling and whorl section.

Also from Devils Point are the poorly preserved type specimens of '*Schloenbachia*' *gracilis* Whiteaves which was redescribed under *Sonninia gracilis* and said to be related to *S. adicra* by Frebold (1957a, p. 48, pl. 19, fig. 1). The two plastotypes, kindly furnished by the Geological Survey of Canada, are distinguished by the much more evolute whorls and the regular simple straight ribs with high-set nodes or spines on at least the last three whorls. *S. gracilis* belongs either to *S. (Euhoploceras)* or to the new Alaskan subgenus *S. (Alaskoceras)* described below.

A related form is the poorly known '*Stiphromorphites schucherti*' Crickmay (1933, pl. 28; *nom. dub.*) from Mount Jura in northern California which was based on a single poorly preserved specimen not available for restudy. This specimen appears to differ from *S. bifurcata* in the shorter secondaries which die out gradually leaving a broad smooth band beside the keel.

The large *S. (Euhoploceras)* from Supplee in east-central Oregon are too poorly preserved to allow specific identification but they resemble the Alaskan species more closely than any other known species.

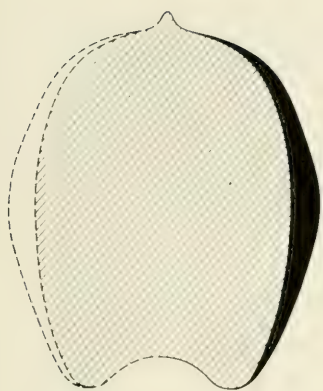
The most closely related named but poorly known species is probably *S. playfordi* Arkell (1954) from the Perth area of West-



Text-fig. 30 a-b. — Cross-sections of *Sonninia (Euhoploceras) bifurcata*, n. sp., $\times 1$. a. Holotype, body chamber somewhat distorted. b. Complete phragmocone of compressed and weakly ornate variant, loc. USGS 12405 (USNM 160239).

ern Australia, because it is said to differ from *S. adicra* chiefly in the secondaries which are more robust on the shoulder. However, the costae of this form are much more densely spaced than in *S. bifurcata* consisting chiefly of simple primaries.

S. bifurcata is distinguished from *S. adicra* Waagen (and its many synonyms; Westermann, 1966) in the stronger secondaries especially on the shoulder of spinose variants and in the generally more distant primaries with stronger developed and longer retained bifurcation.



Text-fig. 31. — Cross-section of *Sonninia* (*Euhoplloceras*) *bifurcata*, n. sp., fragment of large body chamber, left side reconstructed, loc. WA 13w (McM J 1048); $\times 1$.

Measurements. —

	Dmm	W%	H%	U%	H/W	P	Dsp*mm
holotype (body ch.)	106	—	—	—	—	—	—
(phragm.)	85	38	27.5	38	1.38	7-8	$\cong 60$
USNM 160239 (phragm.)	92	36	24	36	1.5	13	0
USNM 160241 (body ch.)	100	—	—	40	—	—	—
(phragm.)	70	32	25	37	1.45	10+	0
USNM 160238 (phragm.)	61	36	28	38.5	1.3	c.7	> 61
"	39	34.5	29.5	41	1.17	5	"
USNM 160240 (body ch.)	110	—	—	—	—	—	—
(phragm.)	80	35	c.25	37.5	1.4	9	—
"	55	c.36	25.5	37	1.43	7.5	30-45
USNM 160242 (body ch.)	c.130	c.34	c.22	—	(c.1.55)	—	—
(phragm.)	53	34	26	40	1.3	8	45
McM J 975 (body ch.)	c.120	—	—	—	—	—	—
(phragm.)	79	37	25	35	1.45	8	$\cong 25$
McM J 981 (phragm.)	150	33	22	41	1.5	12.5	70
"	105	38	27	38	1.43	—	—
"	78	38	27	c.35	1.43	8	—

*Dsp — diameter of the spinose stage.

Sonninia (Euhoploceras?) sp. indet.

Pl. 27, fig. 1

Material. — One internal mold with test remains of one-third whorl phragmocone with remnants of inner whorl and one crushed internal mold of two-fifths whorl body chamber, probably with aperture, from WA 8, upper part (McM. J 959a, b). Upper *E. amplexens* zonule of the basal *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The phragmocone of approximately 70 mm diameter is moderately evolute with compressed subrectangular section and a thin low hollow-floored keel. The costation is extremely weak, blunt, irregular, and restricted to the sides consisting of broad straight or somewhat curved swellings which fade on the rounded umbilical margin and the shoulder. The septal suture is highly complex and nonsuspensive with straight umbilical elements.

The body chamber of approximately 95 mm diameter is evolute, smooth, and probably compressed elliptical to subrectangular in section with faintly keeled venter.

Measurements. —

	Dmm	W%	H%	U%
J 959a (phragm.)	c.70	c.28.5	c.39	(c.26)

Subgenus **SONNINIA (ALASKOCERAS)** Westermann, n. subgen.

Type species. — *S. alaskensis* Westermann, n. sp.

Diagnosis. — An advolute medium-sized subgenus of *Sonninia* with inverse-trapezoidal whorl-section (diverging flanks); primaries blunt and rursiradiate with regular prominent ventrolateral spines retained on body chamber; secondaries obsolete.

Age. — *S. sowerbyi* and *O. sauzei* Zones, Bajocian.

Distribution. — Southern Alaska (+?? Alberta).

Affinities. — *S. (Alaskoceras)* shows close affinities to the spinose and widely umbilicate variants of the European *S. (Euhoploceras) adicra* (Waagen) (cf. Westermann, 1966), such as to the specimen figured by Oechsle [1958, pl. 15, fig. 3; as *S. polyacantha crassiformis* (Buckman)] from the Swabian Jura. Both subgenera have evolute whorls and a small hollow-floored keel set on a weakly rounded, sometimes slightly bisulcate venter, simple long, often rursiradiate primaries with terminal spines which may be molded

in the subsequent umbilical slope, and reduced secondaries. *S. (Alaskoceras)* is distinguished by the inverse-trapezoidal rather than subquadrate whorl section, with diverging gently convex flanks, and the stronger more regular and more ventrad spines which are set on blunt, often almost obsolete, strongly rursiradiate costae. There is little resemblance between *S. (Alaskoceras) alaskensis*, n. sp. and the often associated *S. (Euhoploceras) bifurcata*, n. sp. during any morphogenetic stage.

Some resemblance exists to *Zurcheria* Douville which may have nodes or small thorns developed on the shoulders, such as in *Z. parvispinata* Buckman and *Z. inconstans* Buckman from the *L. discites* Subzone of Dorset, and (?) *Z. pertinax* (Vacek) from the Alps. However, in *Zurcheria* the spines or tubercles are weak, a keel is absent or obsolete, and the whorls are less evolute and more compressed.

Another sonniniid with ventro-lateral nodes is *Haplopleuroceras* Buckman which also agrees in the advolute coiling. It is clearly distinct from *S. (Alaskoceras)* in the subquadrate whorls, the sharp strong prosoradiate costae, the presence of a second line of lateral nodes (with the apparent exception of *H. tobleri* Renz) and of single secondaries, and in the blunt probably solid keel.

Sonninia (*Alaskoceras*) *alaskensis* Westermann, n. sp. Pl. 27, figs. 2-7, Text-figs. 32-33

?1964. *Sonninia* cf. *S. nodata* Buckman, Imlay (Cook Inlet), U.S. Geol. Sur., Prof. Pap. 418-B, p. B33, pl. 2, figs. 1, 2 [Specimen seen; = ? n. subsp.]

Holotype. — Pl. 27, fig. 3a-c; Text-figs. 32a, 33a. Internal mold with test remains of complete phragmocone and distorted fragments of body chamber. Repository: McM. J 1021.

Locus typicus. — Locality WA 10 (scree), south shore of Wide Bay, Alaska Peninsula.

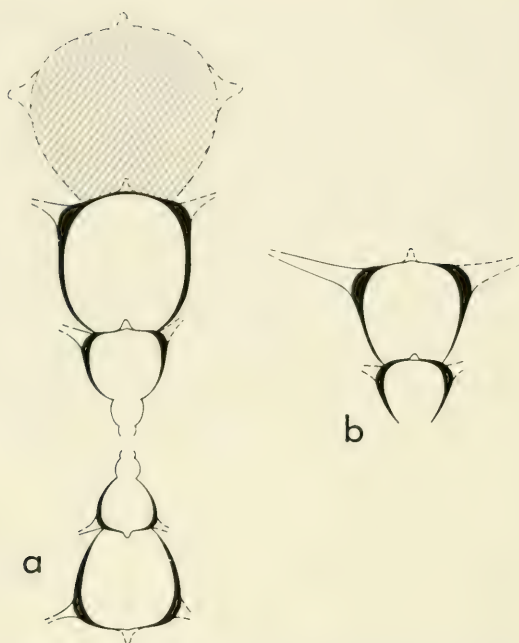
Stratum typicum. — *Pseudocodoceras* zonule of upper Kialagvik Formation.

Age. — (Lower) *S. sowerbyi* Zone (+? *O. sauzei* Zone; ? n. subsp.), Bajocian.

Distribution. — *S. sowerbyi* Zone at Wide Bay; ? also *O. sauzei* Zone of Talkeetna Mountains, Cook Inlet region.

Derivatio nominis. — Self-evident.

Diagnosis. — As for subgenus.



Text-fig. 32 a-b. — Cross-sections of *Sonninia (Alaskoceras) alaskensis*, n. subgen., n. sp.; $\times 1$. a. Composite: phragmocone of holotype, body chamber from loc. WA 13w (McM J 1023), both *Pseudocidoceras* zonule. b. Part of phragmocone at 46 mm D, loc. WA 15 (McM J 1027; cf. pl. 27, fig. 7). Note the hollow-floored ventro-lateral spines up to more than 11 mm in length which were developed from the matrix.

Material. — The holotype, one almost complete specimen with body chamber, and two fragmentary specimens from scree of WA 10 (McM. J 1021 a); one large phragmocone from the basal 10 m of WA 10; one phragmocone fragment from scree of WA 13; two poorly preserved incomplete specimens from WA 13w (McM. J 1023); two almost complete specimens and one phragmocone from 3 m (McM. J 1027), 23 m and scree of WA 15; two almost complete specimens and one damaged phragmocone from USGS 12405. *Pseudocidoceras* zonule and subjacent (?) shales, Kialagvik Formation, southeast shore of Wide Bay.

Description. — The juvenile whorls (6-10 mm D; McM. J 1021 a) are depressed elliptical in section and moderately evolute ($U = 30\%$). During the next one to two whorls (15-20 mm D),



Text-fig. 33 a-b.—Septal sutures of *Sonninia* (*Alaskoceras*) *alaskensis*, n. subgen., n. sp., enlarged. a. Holotype at 17 mm H, 50 mm D, approximated at one-sixth whorl before phragmocone end and probably 'senile'. b. Specimen at 18 mm H, loc. A 13 (McM J 1029).

the whorl section becomes inverse-trapezoidal by flattening and diverging of the flanks and by flattening of the broad venter, and the coiling becomes much more evolute ($U = 40-42\%$). The externside may be slightly bisulcate and carries a small hollow-floored keel. The ornament commences at two to three mm diameter with heavy somewhat fasciculate and probably partly nodose primaries. At about five mm diameter, heavy foldlike rectiradiate costae (five to seven per halfwhorl) develop which terminate on the shoulders of the internal mold in thick knobs marking the base of the prominent hollow-floored spines of the shell. Beyond 10 mm diameter, blunt strongly projected secondaries, about two for each primary, are present beside the venter and the primaries become blunter and rursiradiate. Weaker primaries without spines, which are so common in *S. (Euhoploceras)*, are missing or rare.

Throughout the adolescent and mature growth stages, the whorls are advolute, "riding" with only about 10% overlap on the shoulders of the preceding whorl, so that the spines may be molded into the subsequent shallow umbilical slope. The diverging flank is only weakly convex from the umbilical seam to the shoulder and may become almost smooth on the inner half. Blunt rursiradiate primaries arise mid-laterally and strengthen only slightly toward

the shoulders. The internal molds have large (up to 6 mm in diameter) knobs on the shoulders which in test preservation carry ventrad inclined, extremely strong, hollow-floored spines, eight to nine per halfwhorl. The longest spines measure 11 mm in preserved length which is as much as the corresponding whorl height and width. The venter of the internal mold is usually weakly bisulcate and smooth, while the shell is here flat, with or without shallow sulci, or weakly convex carrying a narrow and low hollow-floored keel. The floors of spines and keel are retained up to and including the first one-fourth whorl of the body chamber. At the end of the phragmocone, the whorl-section may become subquadrate, as in the holotype. On the last whorl of the phragmocone, weak intercalated primaries without spines and densely spaced blunt and strongly projected secondaries are often present.

The body chamber, probably three-fifths to three-fourths whorls in length, is advolute ($U = 50\%$) and, therefore, often exfoliated during fossilization. The flanks remain flattish and divergent but the venter becomes moderately convex. The thin weak keel and the prominent spines are retained to the aperture. The primaries are even more reduced and often become obsolete. Superficially, fine growth lines or lirae may now be present on the flanks. Blunt secondaries are usually developed and can be seen weakly also on the internal mold. The form of the peristome is unknown but it was probably simple according to the almost straight growth lines towards the end of the body chamber.

The septum shows an almost cruciform fluting pattern which is in accordance with the advolute, about as high as broad whorls. This is simply a modified plano-disculate type, similar to the pattern observed in the Alaskan *S. (Euhoploceras)* and *Witchellia*.

The septal suture (Text-fig. 33a-b) resembles closely those of the evolute round-whorled *Sonninia pinguis* (Roemer) and *S. boweri* (Buckman) as recently figured by Schindewolf (1964, text-figs. 193-197) except for the more reduced internal and umbilical elements of *S. alaskensis*; only three full umbilical lobes are developed while there are normally four or five in typical *Sonninia*, this reduction of umbilical elements being interpreted as the result of advolute coiling. As in other sonniniids, the internally located U_1 is asymmetrically trifold to almost bifid; U_1 and U_3 , the ex-

ternal counter-part, are unusually narrow and deep; also U_2 and L may be asymmetrical tending to be bifid. The complexity is low even considering the relatively small size of these probable macroconchs (females).

Affinities.—The affinities to other well-known sonniniids have already been discussed under the subgeneric heading; the closest known relative of *S. alaskensis* is probably among *S. (Euhoploceras)*, such as the European *S. adicra* (Waagen). *Sonninia gracilis* (Whitcaves) from the Alberta foothills is distinguished by the more evolute whorls with stiffer and more regular costae, and it appears that at least the inner whorls had tubercles high on the flanks or shoulders, that the venter of the phragmocone was weakly bisulcate and the whorl section subrectangular to subsquare. *S. gracilis* thus seems intermediate between *S. (Euhoploceras)* and *S. (Alaskoceras)*, but probably closer to the former, particularly resembling evolute variants of *S. (E.) adicra* as figured by Oechsle (1958, pl. 15, fig. 3).

Of particular interest is the single specimen recently described as *Sonninia* cf. *S. nodata* Buckman by Imlay (1964, p. B33, pl. 2, fig. 1, 2) from the *O. sauzei* Zone of the Talkeetna Mountains of southeastern Alaska. Although certainly a close ally of *S. alaskensis*, it is distinguished in the regularly present relatively strong and projected minor costae between the widely spaced spine-bearing primaries. In the absence of a larger sample, the classification of this form as either a new chrono-subspecies or closely related species of *S. (A.) alaskensis* is left open. It is improbable that this is an extremely ornate variant of *S. alaskensis*.

Measurements.—

	Dm	W%	H%	U%	P(spines)
Holotype (phragm.)	58	28.5	33	45	9
"	42	31	32	47.5	8.5
"	29	33	34.5	41.5	9
"	20	37.5	37.5	40	c.8
J 1021 a (phragm.)	30	35	34.5	42	7
"	17.5	37	37	42	7.5
"	11	39	37	34	7
"	6	43	35	30	6.5
J 1023 (body ch.)	88	23	27	50	—
J 1027 (body ch.)	≅ 90	—	—	—	—
(phragm.)	60	29	30	50	8.5
"	45	30	30	48	7

Genus **WITCHELLIA** Buckman, 1889

Type species.—*Ammonites laeviusculus* J. de C. Sowerby, 1824.

The genus was named (Buckman, 1889, *Inferior Oolite Ammonites*, p. 82, footnote 1) for sonniniids with "slight carina [hollow-floored keel] bordered by two furrows which are not seen on the test." Also originally included in *Witchellia* were '*Am.* *sutneri*' Branco, '*Am.* *jugifer*' Waagen, and '*Am.* *deltafalcatus*' Quenstedt.

A few years later, Haug (1893) placed *W. sutneri*, *W. laeviuscula*, and *W. punctatissima* Haug in a single *Witchellia* species group. He, however, also included in *Witchellia* the younger species groups of *Am. romani* Oppel and of *Am. edouardianus* d'Orbigny which Buckman had just separated under *Dorsetensia*, as well as his group of *W. sayni* Haug which Buckman split into various other 'genera.' The ensuing confusion has at length been discussed by P. Dorn (1935, p. 93), Spath (1936, p. 5), Hiltermann (1939, p. 24), and Oechsle (1958, p. 77) and need not be brought up again. The last two authors concluded that *Witchellia* cannot reasonably be separated from *Sonninia*. The distinction of *Dorsetensia* from *Witchellia* is similarly difficult and probably arbitrary.

In the Treatise, Arkell, *et al.* (1957, p. L 270) upheld again the genus *Witchellia* with the diagnosis: "Inclined to be involute compressed, whorls heightening and smoothing early, long before septation ceases; venter narrow, tabulate and carinate, commonly bisulcate, even tricarinate, or becoming fastigate; nucleus as in *Sonninia*"; included in the synonymy were *Zugophorites*, *Sonninites*, *Gelasinites*, *Dundryites*, *Rubriciites*, *Anolkoleites*, and *Zugella*, all of Buckman, 1922-27 (see below).

Lectotype of the type species.—The author examined the lectotype of *W. laeviuscula* (J. de C. Sowerby, 1824, pl. 451, fig. 1; refigured: Buckman, 1908, pl. 5, fig. 1; Arkell, 1956, pl. 34, fig. 1) in the British Museum (Nat. Hist.) (cat. No. 439 50 a). On request by the author, H. K. Howarth developed the left umbilicus and the specimen is, therefore, figured again (Text-fig. 35).

Sowerby's small 'topotypes' from Dundry, Somerset, are all nuclei or immature specimens and probably belong to the Hildoceradidae, such as *Esericeras*, and Hammatoceratidae of the Upper Toarcian and Lower Aalenian. The paratype is described below.

The lectotype, 68 mm in diameter, is completely septate and largely preserved with test. Another one-quarter septate whorl is preserved near the umbilicus which, according to the egressing umbilical seam, represents the end of the adult phragmocone. At 68 mm D, the whorl height is 33 mm, the whorl width 19.5 mm, and the umbilical width 12 mm. There are seven primaries and 23 secondaries on the ultimate one-half whorl. The inner whorls (< 45 mm D) are much more evolute. The flanks of the nucleus (20-25 mm D) slope gently to the umbilical seam but curve more strongly on the intermediate whorls reaching the seam perpendicularly. At the beginning of the ultimate whorl, the flanks converge gently, curving somewhat more strongly besides the keel without forming marked shoulders. The internal mold is closely similar. Subsequently, however, the coiling becomes more involute; the umbilical margin, the steep slope, and the marked but weak shoulders and sloping narrow ventral bands of the adult shell develop; the keel is now strong, high, and hollow-floored. The internal mold is typically tabulate-unicarinate with moderately sharp shoulders and a low blunt keel; however, sulci are absent.

The costation of the inner evolute whorls, as seen in the developed umbilicus, is irregular, partly fasciculate, bearing small bullae of different strength. The ultimate phragmocone whorl has distant blunt, slightly to markedly falcoid principal ribs which are composed of short prosoradiate primaries curving into single relatively strong secondaries. The greatest, although modest, strength is reached on the middle of the flanks. Other much weaker secondaries arise at first by fasciculation and later by furcation and intercalation. All ribs project strongly and die out a short distance from the keel.

The septal suture is partly preserved. The E/L and L/U₂ saddles are of similar size and weakly frilled, L is moderately wide and symmetrically trifid with rather thin long stems. The umbilical lobes are nonsuspensive.

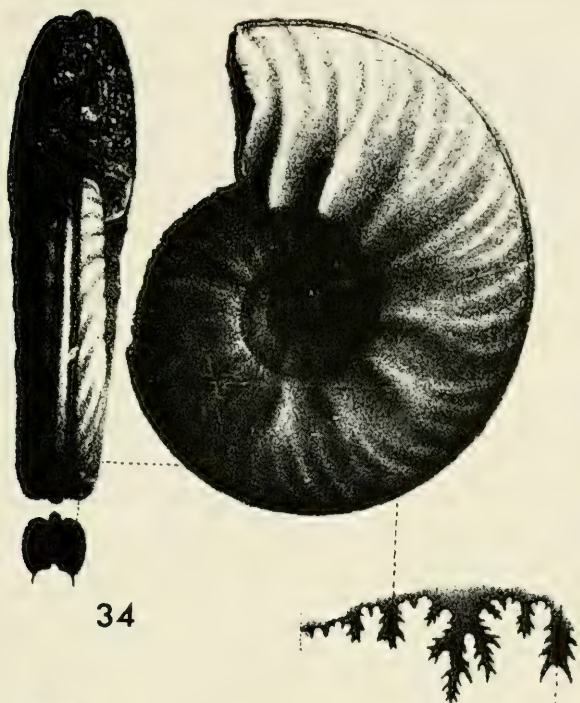
Other specimens of the type species.—The paratype of *W. laeviuscula* (J. de C. Sowerby, 1924, pl. 451, fig. 2; Buckman, 1908, pl. 14, fig. 2) came also from Dundry in Somerset. This small (22.5 mm D) evolute specimen of which the ultimate egressing one-third whorl appears to belong to the adult body chamber, may

be a microconch. However, there is hardly any way of comparing this specimen with the much larger lectotype except for the inner flanks of the inner whorls exposed in the umbilicus. While the lectotype is deeply umbilicate and tuberculate at comparative size, the paratype is strongly compressed and has only weak fasciculate costae. The paratype becomes tabulate (but not sulcate) only on the body chamber and has a sharp thin keel.

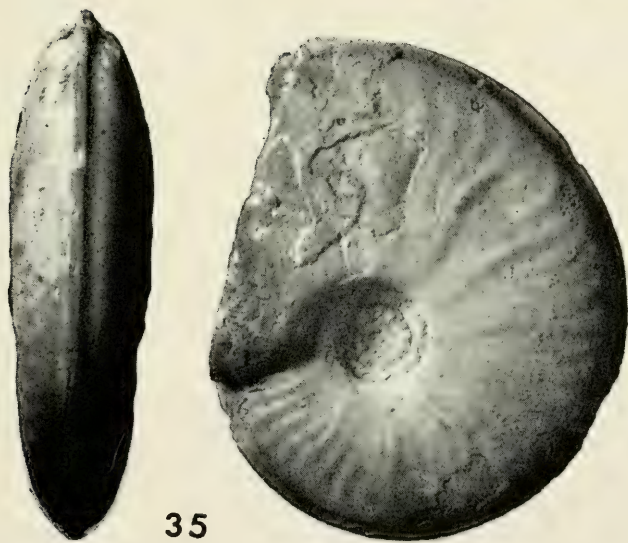
Significantly, Buckman placed in *W. laeviuscula* also more evolute and typically tabulate to bisulcate large sonniniids. However, these specimens came mostly from Osborne in Dorset. One of these specimens (Buckman; Type Ammonites, pl. 745) which was refigured in the Treatise (Arkell, *et al.*, 1957, p. L 269) closely resembles the lectotype except that the venter of the internal mold is markedly bisulcate. My study of unfigured specimens in the Buckman collection (Geological Survey Museum, London, U.K.) indicates that there is an intergrading morphological sequence from bisulcate to tabulate internal molds and that, consequently, the lectotype is a marginal variant of a single, usually more or less strongly bicarinate species. This might already have been recognized by Buckman (1920, Type Ammonites, pl. 168) as suggested by his invalid determination of *W. spinifera* as substitute "genolectotype." *W. spinifera*, here placed in synonymy with *W. laeviuscula*, is based on an almost complete, relatively small, and markedly bisulcate specimen which appears to be close to the mean of the species variation.

Buckman's collection also suggests that there is continuous variation from the involute *W. laeviuscula* morphotype to the more evolute and, as usual, stronger ornate forms. Thus, *W. platymorpha* Buckman (1926) is considered another variant of *W. laeviuscula*; the venter of the internal mold is bisulcate-tricarinate on the phragmocone and strongly tabulate on the body chamber. At about 70 mm diameter, the umbilicus suddenly narrows from 28% to 22-24% so that the adult specimen resembles the lectotype in this respect. Yet the inner whorls match *W. sutneri* (Branco) with which the specimen had originally been identified by Buckman.

Witchellia sutneri (Branco).—The author has searched for the holotype which appears to be lost. *W. sutneri* (Branco, 1879, pl. 5, fig. 2; reproduced here in Text-fig. 34) came from the S.



34



35

Text-fig. 34.— Holotype of *Witchellia sutneri* (Branco), reproduction of original figure (Branco, 1879, pl. 5, figs. 2 a-c, 5a), St. Quentin, Lorrain; approx. $\times 1$.

Text-fig. 35.— Lectotype of *Witchellia laeviuscula* (J. de C. Sowerby), left umbilicus newly developed, Inferior Oolite, Dundry, Somerset. Note irregular fasciculate costae and lateral tubercles of nucleus visible in umbilicus; $\times 1$.

sowerbyi or *O. sauzei* Zone of St. Quentin near Metz in Lorraine, France, and was amply described. Branco listed the following measurements: estimated complete diameter 100 mm, preserved diameter 61 mm, whorl height 27 mm, whorl width 17.5 mm, umbilical width 18.5 mm. The whorl section is less compressed than shown in the figures and is said to be square except for the ultimate half-whorl, with steep umbilical wall grading into flat sides and bisulcate (bisculcate-tricarinate in drawing) venter beyond 20 mm diameter. The costae are said to originate simply or in pairs from small nodes near the umbilicus. The simple septal suture was figured with short U_2 as in *Sonninia sowerbyi*. According to Branco, the inner whorls resemble *S. gingensis* (Waagen) [? a synonym of *S. corrugata* (Sowerby)] and the penultimate whorl *S. adicra* (Waagen). According to the drawing, the ultimate half-whorl of the holotype has seven bullae-like primaries and 22 strongly projected secondaries. At least toward the end, the primaries continue into one of the secondaries which are, therefore, of uneven strength. The missing last whorl was apparently evolute, according to the slightly egressing umbilical seam.

The study of Buckman's collection of evolute *Witchellia* from Osborne in Dorset suggested to me strongly that all alleged species are members of a single intergrading morphological sequence and conspecific with *W. sutneri* (Branco). *W. falcata* Buckman and *W. actinophora* Buckman, 1926, had originally been so identified by Buckman (1889), and *W. glauca* Buckman (1925) was distinguished because of the presence of irregular nodes only.

Species group, plexus or superspecies *W. laeviuscula* - *W. sutneri*.—Finally even the separation of the involute *W. laeviuscula*-type forms from the largely contemporary, more evolute *W. sutneri*-type forms could be purely arbitrary. In 1893 Haug (p. 303) spoke of the total morphological intergradation in the Elsassian occurrence, and the material from the *W. laeviuscula* Subzone (upper *S. sowerbyi* Zone) of Frogden Quarry near Osborne in Dorset appears to support this opinion. However, the evidence is still incomplete particularly because most specimens consist only of phragmocones and vary greatly in size, their exact morphogenetic stage and the apertures being unknown. The similar size range of the involute and more evolute forms speaks against their interpretation as corresponding sexual dimorphs.

If this mainly northwestern European (England, France) *Witchellia* 'species group' is arranged into a morphological sequence, it becomes obvious that coiling, whorl section, and costation co-vary, *i.e.* ranging from involute, finely ornate, and tabulate to evolute, coarsely ornate, and bisulcate forms (Text-fig. 39). This sequence of alleged 'species' is:

W. patefactor Buckman, 1923

W. laeviuscula (J. de C. Sowerby) 1824

W. spinifera Buckman, 1920

W. platymorpha Buckman, 1925

W. actinophora Buckman, 1926

W. glauca Buckman, 1925

W. falcata Buckman, 1926

W. sutneri (Branco) 1879

It appears advisable for the time being to distinguish the two species *W. laeviuscula* and *W. sutneri* and to regard the other names as synonyms by arbitrary central division of this morphocline between '*W. platymorpha*' and '*W. actinophora*'.

The *W. laeviuscula* - *W. sutneri* species group, plexus or super-species was abundantly known from southern England and eastern France where it marks the upper *S. sowerbyi* Zone, *i.e.* the *W. laeviuscula* Subzone. *W. sutneroides*, n. sp. from southern Alaska is also a member of this 'plexus.'

Older Witchellias.—The first witchellias occur in the middle *S. sowerbyi* Zone, the *S. trigonalis* Subzone, of southern England and were named *Zugophorites zugophorus* Buckman (1922) and *Gelasinites gelasinus* Buckman (1925). These generic names are certainly synonymous with *Witchellia* and both forms may well be conspecific. There is a possibility that they are conspecific with *W. sayni* Haug (1893, p. 309; for *Ludwigia corrugata* Douville, non Sowerby) from eastern France. *Zugophorites* [syn.: *Gelasinites*] is at best a subgenus of the slightly younger *Witchellia* described above from which it is distinguished by the wider umbilicus and the more regular costae without bullae-like inflated primaries. *W.* ('*Zugophorites*') was probably directly ancestral of the closely related and only slightly younger *W. laeviuscula* - *W. sutneri* 'plexus.'

Related genera.—Similar taxonomic problems as discussed

above arise on the generic level. Many authors working on this group have concluded that there are no distinct morphological limits between *Witchellia* and *Sonninia* on the one hand and between *Witchellia* and *Dorsetensia* on the other.

The inclusion in *Witchellia* of several moderately involute, more or less discoidal, and fastigate to weakly tabulate genera mainly from the *O. sauzei* Zone, such as in the Treatise (Arkell, *et al.*, 1957, p. L 270), probably does not reflect phyletic relationship. These forms miss the bisulcate or at least clearly tabulate-unicarinate venter of *Witchellia* and have the sharp umbilical margin and often the simple costation of *Dorsetensia*. It appears totally arbitrary to place the tabulate-unicarinate '*Hyalinites*' Buckman (1924) in *Dorsetensia* but the similar '*Dundryites*' Buckman (1926) in *Witchellia* simply because the latter is slightly more involute. The discoidal '*Rubriileites*' Buckman (1926) can hardly be distinguished from *Dorsetensia* of the *D. tecta-subtecta* group. However, '*Rubriileites*' and '*Dundryites*' bear the irregular primaries of *Witchellia*. '*Anolkoleiites*' Buckman (1926) is an extremely involute and compressed form of this same group.

Sonninites Buckman (1923) is based on a large phragmocone of the compressed, moderately involute, almost fastigate and smooth *S. felix* Buckman which has a sharp umbilical margin; the inner whorls ("paratype") are keeled without tabulation and almost evenly and simply costate, except for the nucleus of 20 mm diameter which shows fasciculation as in *Witchellia* and *Sonninia*; *S. simulans* Buckman has irregular nodes on the nucleus; however, *S. celans* Buckman is a typical oxycone. It appears advisable, therefore, to retain *Sonninites* as a subgenus (or ? genus) for this intermediary group which possesses adolescent and adult characters most similar to *Dorsetensia* but retains the juvenile whorls of *Witchellia* (? and *Sonninia* or *Sonninia*). *Fissilobicerus* Buckman (1919) is distinguished by greater inflation and the complex septal suture.

The intricate relationship of *Witchellia* with typical *Sonninia* concerning especially the *W. laeviuscula* - *W. sutneri* 'plexus' was noted especially by Hiltermann (1939, p. 125) and supported by Oechsle (1958, p. 77). There is no single diagnostic feature separating them. 'Typical' *Witchellia* costation occurs in *Sonninia corrugata* (Sowerby), *S. alsatica* Haug, and other species of *Sonninia*.

While many *Sonninia* species become smooth, costation may persist onto large body chambers in *Witchellia* such as in the Alaskan species described herein; strong infraspecific variation in the diameter of the costate stage is often apparent. Even the bisulcate venter of *Witchellia* may be present at least on the inner whorls of *Sonninia*.

Dimorphism. — The described *Witchellia laeviuscula* - *W. sutneri* 'plexus' is apparently totally macroconchiate (female), with the possible exception of '*W. glauca*' Buckman which is fully grown at 75 mm diameter and may be identical with '*Spatulites spatians*' Buckman, a microconch of 59 mm diameter bearing prominent lappets.

The corresponding microconchs (males) to 'typical' *Witchellia* were described under the generic names of *Pelekodites*, *Nannoceras* (?) Buckman, 1923, and especially under *Maceratites* and *Spatulites*, Buckman, 1928, from the stratotype and type locality of *W. laeviuscula*. All were combined into the single genus *Pelekodites* in the Treatise (Arkell, *et al.*, 1957, p. L 270) which includes most lappet bearing sonniniid microconchs.

The type species of *Pelekodites*, *P. pelekus* Buckman, 1923, is from the *S. trigonalis* Subzone (middle *S. sowerbyi* Zone) of Dundry, Somerset. It is a small, moderately evolute microconch with slightly depressed whorl section, weak only slightly fasciculate rur-siradiate costae, and lappets, and it appears to match the inner whorls of the macroconchiate *W.* ('*Zugophorites*') from the same subzone. '*Nannoceras nannomorphum*' Buckman, 1923, is probably a somewhat stronger ornate variant of *P. pelekus*. '*Spatulites*' Buckman, 1928, with the only species *S. spatians* Buckman, 1928, and the almost identical '*Maceratites*' Buckman, 1928, with the only species *M. aurifer* Buckman, 1928, came also from the *W. laeviuscula* Subzone of Dundry. They are more compressed and more strongly costate than *Pelekodites*, with irregular fasciculation and some bul-lae. There is close correspondence to the associated macroconchiate *Witchellia laeviuscula* - *W. sutneri* 'plexus.' '*Spatulites*' and '*Maceratites*' are certainly not distinct even on the subgeneric level and both type species may be conspecific; '*Spatulites spatians*' has page priority.

If *Zugophorites* [syn.: *Gelasinites*] is distinguished as subgenus of *Witchellia*, it may be advisable to classify the possibly correspond-

ing respective microconchs *Pelekodites* and *Spatulites* at the same level and to place all three in *Witchellia*. However, microconchs and inner whorls of macroconchs are in need of reinvestigation and the specific dimorphic correspondences, especially of typical *Pelekodites*, are still poorly known. If one places *Sonninia* and *Witchellia* in a single genus, as a number of colleagues prefer, *Pelekodites* (*s.l.*) is also to be included in *Sonninia* as a subgenus. With little new evidence available it appears advisable for the time being to adhere to the classification of the Treatise and to retain *Pelekodites* as a genus; however, *Spatulites* is tentatively distinguished as a subgenus.

Witchellia sutneroides Westermann, n. sp.

Pls. 28-31;
Text-figs. 36-38, 40-41

Holotype. — Pl. 28, figs. 1a-c; Text-fig. 36a; well-preserved (? incomplete) phragmocone, internal mold with part of shell. Repository: USNM 160243.

Locus typicum. — U.S. Geol. Survey Mesozoic locality 21251, southeastern shore of Wide Bay, Alaska Peninsula.

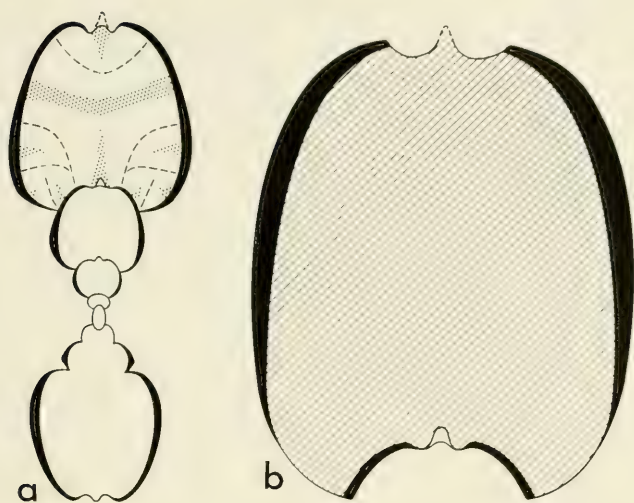
Stratum typicum. — *Pseudocidoceras* zonule, supposedly about 160 m below top of Kialagvik Formation.

Derivatio nominis. — Resembling *W. sutneri* (Branco).

Age. — Middle to upper *S. sowerbyi* Zone, Bajocian.

Diagnosis. — A large evolute species of *Witchellia*, typically bisulcate-tricarinate, usually throughout strongly costate including shoulders and lateral carinae; simple ribs on outer one to two whorls.

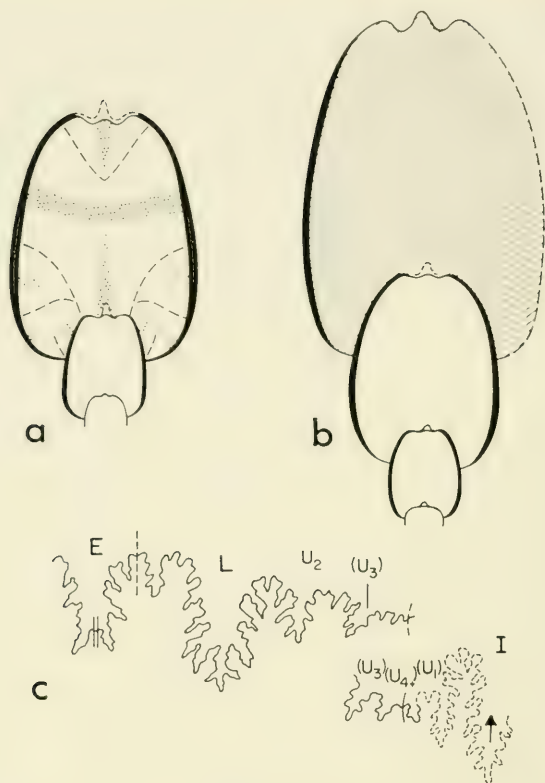
Material. — The holotype and two phragmocones with body chamber fragments from USGS 21251 (USNM 160249, 160248); two complete phragmocones, one with fragment of body chamber from USGS 12405 (USNM 160244, 160247); fragmental body chamber from USGS 19869; one complete juvenile specimen from USGS 19922; one phragmocone fragment and one body chamber fragment with test from WA 10 at 14-15.5 m (McM J 949); one (?) deformed body chamber fragment from WA 11 at 19 m (McM J 945); fragments of single large phragmocone with incomplete body chamber from WA 11 at 22 m (McM J 948); one large body chamber fragment from WA 13, scree (McM J 950); one (?)



Text-fig. 36 a-b. — Cross-sections of *Witchellia sutneroides*, n. sp.; $\times 1$. a. Holotype, phragmocone with septal face (lobe axes shaded, saddle axes indicated by dashed lines). Note tricarinate internal mold and high hollow-floored keel. b. Fragment of large body chamber, loc. WA 13 (McM J 950).

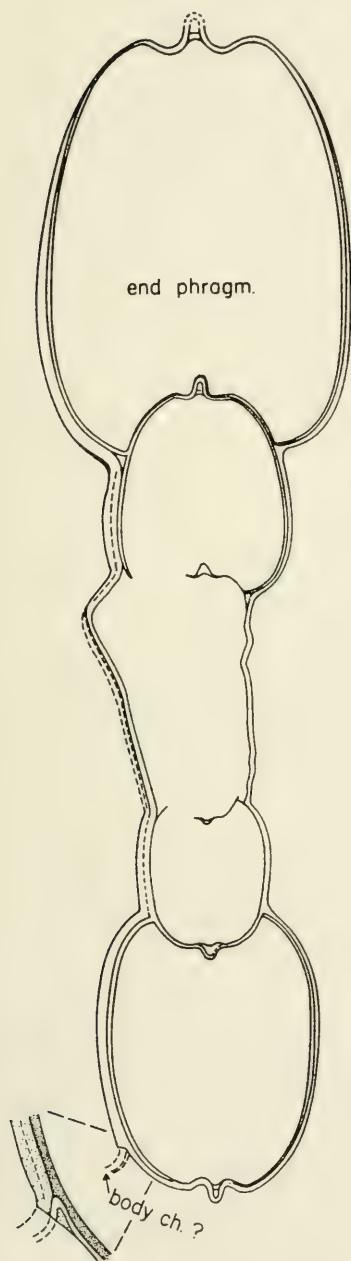
immature specimen with incomplete body chamber from WA 13 at 9 m (McM J 947); one deformed phragmocone with incomplete body chamber from WA 13W, scree (McM J 946). All specimens are well-preserved internal molds, some with parts of the shell, from the (upper) *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The nucleus can only be seen on the holotype; the second whorl, at a diameter of about 2 mm, bears blunt lateral nodes or bullae. At 3-4 mm diameter, the moderately evolute whorls are depressed oval in section with a blunt low keel bordered by weak sulci. There are eight primaries on this whorl which terminate on the middle of the flanks in rounded nodes; secondaries are missing. Subsequently, the strong costation becomes highly irregular, fasciculate in groups of two to four, and single ribs swell to bullae-like primaries. The number of bullae and fasciculations increases at about 30 mm diameter from four to five to seven to nine per halfwhorl. However, bullae are not developed in the more involute and stronger compressed variants which have 9-14 irregular blunt ribs per halfwhorl.

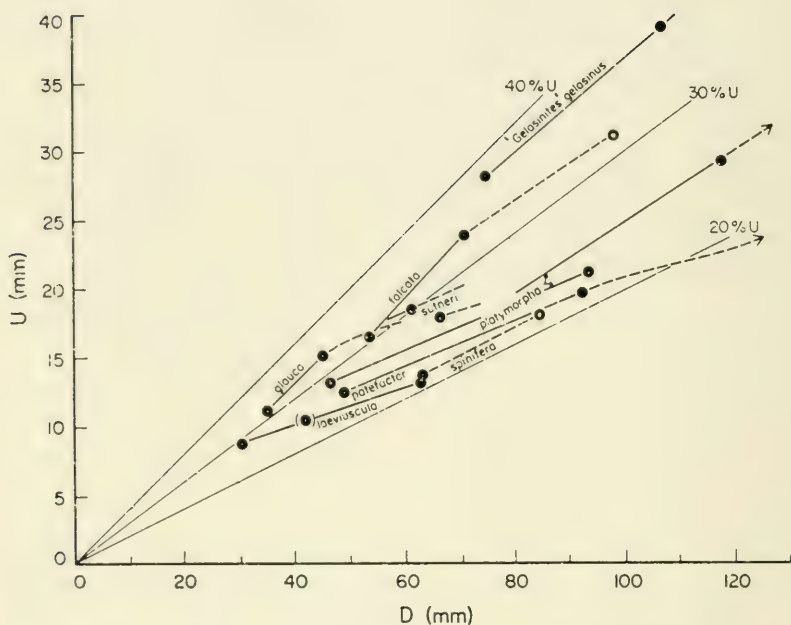


Text-fig. 37 a-c.—Cross-sections and septal sutures of *Witchellia sutneroides*, n. sp., $\times 1$. a. Compressed variant, part of phragmocone with septal surface (see Text-fig. 36 a), loc. USGS 12405. b. Part of phragmocone and body chamber of average specimens, loc. USGS 21251 (USNM 160249). c. Septal sutures at 18 mm H, 42 mm D (above) and at 32 mm H (solid line: same specimen as in 37b, dotted line: loc. WA 11 (McM J 948).

At 20 mm diameter, the whorl section of the holotype becomes subsquare and finally moderately compressed subrectangular. The slightly converging whorl sides flatten out, rounding into the low steep umbilical wall and into the broad venter which is usually bisulcate-tricarinate. The keel of the shell is high and bladelike but reduced resembling the carinae on the internal mold, while the sulci are somewhat shallower than on the internal mold. The evolute, less ornate forms become more compressed and almost



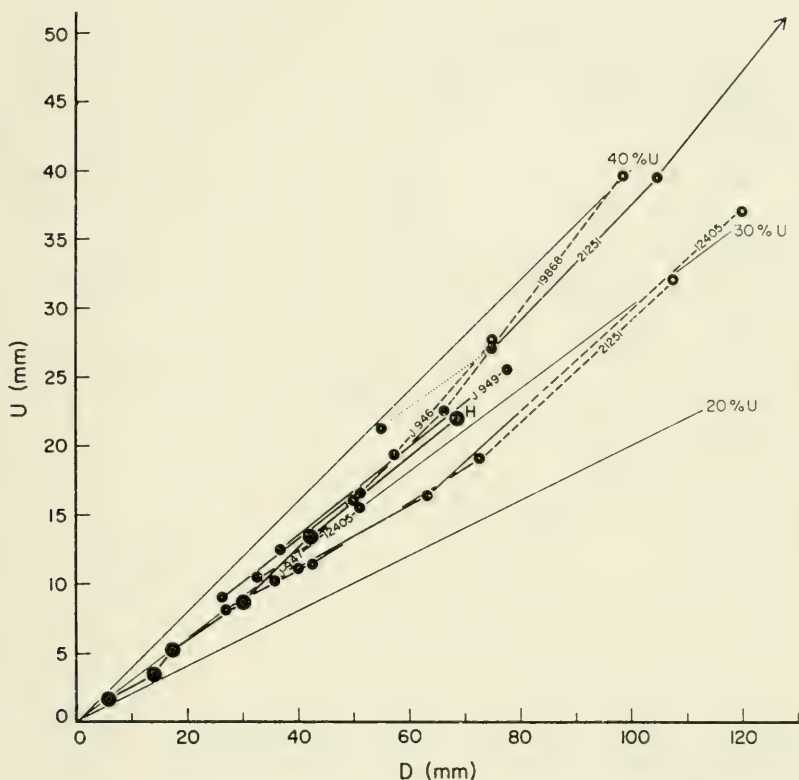
Text-fig. 38. — Cross-section of *Witchellia sutneroides*, n. sp., largest phragmocone with apparent shell duplication (cf. Pl. 31), loc. USGS 21251 in the *Pseudocidoceras* zonule (USNM 160248); $\times 1$.



Text-fig. 39.—Scatter with growth lines for relative umbilical width (U:D) of the *Witchellia laeviuscula-sutneri* group, *W. laeviuscula* Subzone of England, and of '*Gelasinites*' *gelasinus* Buckman, *S. trigonalis* Subzone of England. Note the subcontinuous distribution from 21 to 34% U throughout the mature whorls of the phragmocone (dots and solid lines). A more or less arbitrary division at about 29% U separates the *W. laeviuscula* 'plexus' from the *W. sutneri* 'plexus'.

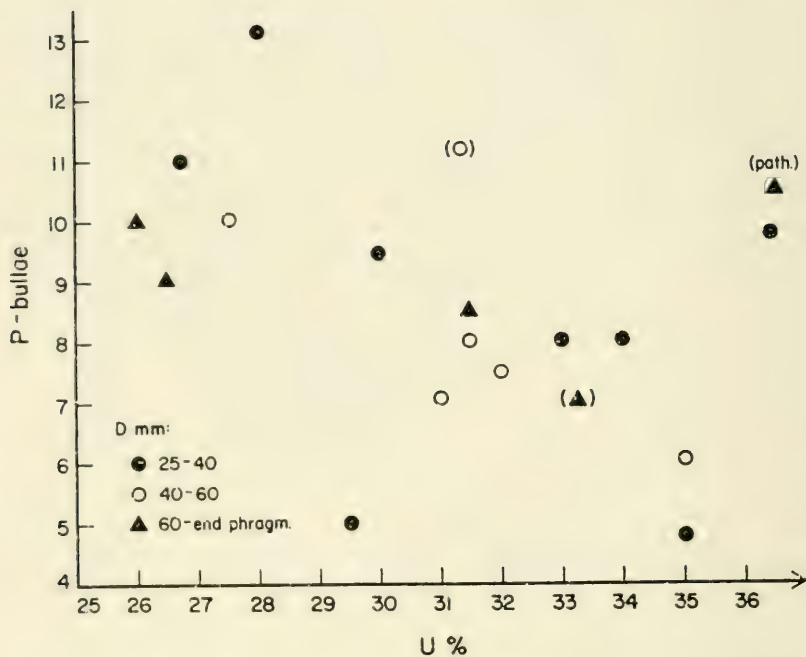
ovate in whorl section with narrower venter and weaker developed sulci.

At 35-50 mm diameter, the costation becomes bifurcate or, more rarely, trifurcate after extension of the lower-lateral bullae into rectiradiate or somewhat prosoradiate primaries. The primaries, 8-13 per halfwhorl, reach their maximum elevation at about two-thirds whorl height and usually continue straight or slightly rursiradiate into one of the swollen secondaries. The secondaries, 18-25 per halfwhorl, project strongly on the rounded shoulders and reach the outer carinae in full strength. In the more compressed and more involute forms, there are mostly somewhat irregular blunt much weaker ribs.



Text-fig. 40.— Scatter with growth lines for relative umbilical width (U:D) of *Witichellia sutneroides*, n. sp., holotype (H) and catalogue or locality numbers of other specimens indicated, all from the *Pseudocidoceras* zonule of Wide Bay. Note that the mature phragmocone (dots and solid lines) varies from 26 to 38% U, resembling the *W. sutneri* 'plexus' and '*Gelasinites*' (Text-fig. 39).

At 80-100 mm diameter, the principal ribs become more numerous by continuation of the primaries into single strengthened secondaries while the others become reduced. The last whorl of large shells bears strong, mostly simple, rectiradiate, projected to somewhat rursiradiate costae, resembling large *Euhoploceras*. This strong ornament is usually retained up to the end of the body chamber, with the exception of the more involute and compressed variant where it becomes obsolete. All body chambers retain the striking bisulcate-tricarinate venter.



Text-fig. 41.—Scatter for 'ornament' (P-primaries, or bullae per half-whorl) vs. 'coiling' (relative umbilical width, $U:D \times 100$) at different phragmocone diameters of *Witchellia sutneroides*, n. sp., all from the *Pseudocidoceras* zonule of Wide Bay. There may be some weak negative correlation, at least for the smaller size groups, i.e., the more evolute shells may tend to bear fewer (stronger) primaries or bullae.

The high infraspecific variation is another example of the "(1st.) Buckman Law of Covariation" (Westermann, 1966). There is a complete morphological transition from involute, strongly compressed and weakly ornate forms to evolute, weakly compressed and strongly ornate forms. In addition, there is probably a smaller form. The adult diameter varies from about 100 to more than 200 mm, umbilical width from 26% to more than 36% in phragmocones of similar size, whorl section (H/W) of adult phragmocones between 1.15 and 1.4 (? 1.45) and of body chamber between 1.25 and 1.6 (Text-fig. 40). The number of primaries is difficult to determine because they may occur singly or in the form of bullae-like bundles. The number of secondaries varies between about 18

and 28 per halfwhorl, but changes little on the last whorls within specimens. The plot of relative umbilical width against number of primaries/bullae suggests weak negative correlation at different growth stages (Text-fig. 41). This variation is pene-contemporary since no morphological change was observed throughout the restricted vertical range of this species.

The septum is fluted according to the planodisculate type (Text-figs. 36-37). The major lateral lobe-axis L-L is concave fusing medially with the incomplete central lobe-axes of I. The incomplete lobe-axis of U_2 is strongly reduced. The incomplete reduced median lobe-axes of E ends at the curved E/L-E/L (external saddle) saddle-axis. In accordance with the different strength of these septal elements, the suture has a small E, a large E/L saddle, a large L (which is trifid with long thin endings); and small (non-suspensive) umbilical elements of which U_2 is usually only one-half the size of L. The adjacent major indentation is either all or part of U_3 . The internal suture has a deep narrow I and a single (paired) large I/U saddle. The general complexity (frilling) is moderately high.

Comparison. — This species closely resembles *Witchellia sutneri* (Branco) from the *S. sowerbyi* Zone of Europe, from which it is distinguished by the stronger costation especially on shoulders and carinae of the last whorls and by the well-developed bisulcate-tricarinate venter of shell and internal mold of phragmocone and body chamber. Also, *W. sutneri* appears to have more tightly coiled outer whorls.

Two small specimens resemble *W. sutneri* (original figures reproduced, Text-fig. 34) so closely that they were originally identified with that species; they are especially close to '*W. platymorpha*' Buckman (Type Ammonites, pl. 580) from the *W. laeviuscula* Subzone of Dorset. However, these Wide Bay specimens appear to intergrade with the bulk of the sample with which they are, therefore, regarded conspecific.

Particularly, the widely umbilicate last whorl (including body chamber) of *W. sutneroides* strongly resembles *W.* ('*Zugophorites*') Buckman from the *S. trigonalis* Subzone (middle *S. sowerbyi* Zone) of Dorset. However, the English forms are bisulcate on the internal mold only and their costation is much weaker becoming obsolete on the last whorl.

W. sutneroides is, therefore, morphologically almost intermediate between the European forms of the middle and upper *S. sowerbyi* Zone, respectively, but distinct in the stronger costation especially on the shoulders. Significantly, the same feature also distinguishes the associated *S. (Euhoploceras) bifurcata*, n. sp. from its European relatives.

Of special interest are two species [*nomina dubia*] described from British Columbia and unnamed specimens from Alberta. The plastercasts were kindly furnished by the Geological Survey of Canada. "*Sonninia skawahi*" McLearn (1926) from talus of the Hazelton Group at Hudson Bay Mountain, British Columbia, was based on a single incomplete and poorly preserved specimen. The small conch (52 mm D) is evolute ($U=38\%$), compressed elliptical to slightly subrectangular in whorl section, and has strong simple costae bundled in pairs near the umbilicus. The internal mold is strongly keeled and narrowly bisulcate. Although superficial similarity with *W. sutneroides* exists, the poorly known Canadian form is distinct in the absence of primaries or elongated bullae and in the reduced lateral carinae of the venter. "*Sonninia silveria*" McLearn (1926), found in the same scree, is based on a single distorted and incomplete poorly preserved phragmocone, possibly with part of the body chamber. The inner whorls up to 45 mm diameter resemble evolute, bisulcate, and fasciculate variants of *W. sutneroides*, but the British Columbia form becomes subsequently almost smooth and the venter simply keeled on narrow tabulation. Both specimens may well belong to a single (? new) species of *Sonninia* but the specific names are to be regarded as *nomina dubia* (they were omitted in the "Illustration of Canadian Fossils" by Frebold, 1964).

Sonninia sp. indet. was described from the Fernie Group at Devils Point at Lake Minnewanka near Banff, Alberta (Frebold, 1957a, p. 49, pl. 19, fig. 2). The figured specimen is a fragment of a large evolute sonniniid with subrectangular whorl section, moderately bisulcate-tricarinate venter of the internal mold, and simple rectiradiate projected weak costae which bundle on the antepenultimate whorl. The plastercast of this and of another fragment were kindly furnished by the Geological Survey of Canada. Both specimens were apparently associated with the *S.* (? *Euhoploceras*) cf. *bifurcata* (*op. cit.*, pl. 20; see *S. bifurcata*). This form resembles

closely *Witchellia* ('*Zugophorites*') and may be identical with the British Columbia forms described above.

Shell duplication. — The largest specimen (USGS 160248) with an estimated complete diameter of 200-220 cm shows unique thickening and continuation of apparent test from the sides of the last phragmocone whorl onto the exposed sides of the penultimate whorl and over the plugged umbilicus where the inner whorls are not preserved (Text-fig. 38; Pl. 31). On the left side of the conch, this apparent secondary test is only about one-half millimeter thick, but on the right side it is duplicated (locally triplicated ?) and one to two mm thick. This apparent test generally rounds off the sharp angles at the umbilical seams and seems to have been continuous also onto the missing body chamber. While superficially closely resembling ammonite test and internally showing similar although often duplicated layering, the material consists of coarsely crystalline calcite (X-ray fluorescence inspection by B. J. Burley) which either could have been derived from ammonite test by diagenetic alteration or be little altered nonbiogenic calcite.

This shell duplication phenomenon is probably best explained by late diagenetic nonbiogenic processes in which the surrounding sediment was separated from the shell (or dilation within the test) due to differential compaction and the thus developed supplementary natural mold subsequently filled with calcite by slow lateral secretion. It appears unlikely that this apparent shell is true test secreted by the fully grown animal asymmetrically over both the entire sides of the conch after destruction of the inner phragmocone whorls. Such magnitude of secondary shell secretion is unknown in the cephalopods.

While this article was in press, several instances of 'diagenetic conch hypertrophy' resembling this case were described and analysed by R. Hollmann (1968, Neues Jahrb. Geol. Paläontol., Abh. 103, pp. 305-334) from Upper Jurassic ammonites of East Africa.

<i>Measurements.</i> —	Dmm	W%	H%	U%	P/bullae	S
Holotype (phragm.)	69	32	40	31.5	8-9	20
"	42	33.5	39	31	7	c.18
"	30	33	35	29.5	5-9	—
"	17	38	37	33	4-7	—
"	13	44.5	34.5	38	4.5	—
"	6	50	38	32	4.5	—

	Dmm	W%	H%	U%	P/bullae	S
USNM 160249 (body ch.)	108	c.26	40.5	30	—	—
(phragm.)	72	29	44.5	26.5	9	23
"	42	32	43	27.5	c.10	23
"	27	32	42.5	30	9.5	—
USNM 160248 (body ch.)	≥ 200	—	—	—	—	—
(phragm.)	152	25.5	33	40.5	11.5	21
"	106	28	36	38.5	11	21
"	75	32	37	36	10	—
"	58	c.31	c.38	c.37	c.10	—
USNM 160245 [<i>W. cf. sutneroides</i>]						
(body ch.)	100	c.27	c.35	41	c.14	19
(phragm.)	66	30.5	39.5	34	—	—
"	51	29.5	37.5	32	7.5	—
"	26	—	—	35	5	—
USNM 160244 (body ch.)	120	c.26	39	31	(13.5 obs.)	25
(phragm.)	(c.80) 63	34	45	26	10	24
"	40	32 ±	38.5	27	11	24.5
USNM 160247 (phragm.)	57	33	39	31.5	8	c.25
"	32	31.5	37.5	33	c.8	c.27
McM J 945 (body ch.)	c.100	c.24	c.30	—	8-10	—
McM J 946 (body ch.)	c.78	c.36	c.45	c.35	7.5	c.21
(phragm.)	58	31	39.5	33	c.7	c.21
"	41	—	—	35	c.6	25
McM J 947 (body ch.)	50	c.28+	38	32	11	—
(phragm.)	36	35	39.5	28	13.5	—
McM J 948 (body ch.)	c.150	c.25	c.37	—	11.5	—
(phragm.)	c.130/c.70	c.34	c.44	—	8.5	—
McM J 949 (phragm.)	78	33	38.5	c.33	c.12	—
"	37	34	c.35	c.34	8	22
McM J 950 (body ch.)	c.190	c.25	c.31.5	—	c.14.5	(c.14.5)

Genus **PELEKODITES** Buckman, 1923

Type species. — *P. pelekus* Buckman, 1923.

The genus has been discussed above in the introduction to *Witchellia*.

Pelekodites cf. P. pelekus Buckman, 1923

Pl. 32, figs. 1,2

Material. — Two complete internal molds with lappets, from WA 10 at 11 m (McM J 1028a, b). *Asthenoceras* concretion, *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — Both specimens are dwarfs (19 and 26 mm diameter). The inner whorls, as seen in the broken smaller specimen, are evolute and depressed elliptical to subrectangular in section with clearly bisulcate venter and blunt, apparently solid keel. While the smaller phragmocone of only 13 mm diameter retains

this whorl section to the end, the slightly larger one becomes sub-square. The body chamber of only one-half whorl length becomes more evolute and somewhat compressed elliptical in section, with simple narrow tabulations beside the blunt keel. Both specimens have lateral lappets which are probably incompletely preserved.

The costation consists of moderately strong irregularly fasciculate costae which are almost rectiradiate and slightly flexed on the phragmocone, but markedly rursiradiate and terminally projected on the body chamber. The costation is reduced, finally becoming obsolete on the last one-fourth whorl.

<i>Measurements.</i> —	Dmm	W%	H%	U%	P
McM J 1028 a (body ch.)	26	27	34.5	40	—
(phragm)	16.5	36	32	36	15
McM J 1028 b (body ch.)	19	31.5	34.5	38.5	—
(phragm)	13/12	41.5	37.5	33	c.16

Subgenus(?) **PELEKODITES (SPATULITES)** Buckman, 1928

(Syn. *Maceratites* Buckman 1928)

Type species. — *S. spatians* Buckman, 1928.

The probable *Witchellia* — *P. (Spatulites)* dimorphism has been discussed above in the introduction to *Witchellia*.

Pelekodites (spatulites?), n. sp. aff. **P. spatians** (Buckman)

Pl. 32,
figs. 3, 4

Material. — One phragmocone with part of body chamber, including the peristome with (incomplete ?) lappets, phragmocone partly crushed, internal mold with test remains, from locality WA 11 at 22m (McM J 939); a second much smaller specimen with incomplete apparently adult body chamber, moderately preserved and deformed, from the same locality at 32 m (McM J 1294). *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The phragmocones of the two specimens are only 35 and 25 mm in respective diameters. The umbilicus is wide and shallow and the whorl section compressed subelliptical, slightly subrectangular. The venter is bisulcate-tricarinate on the internal mold, while the test has a high hollow-floored keel and broad sulci, at least above 17 mm diameter. Under 17 mm diameter,

the venter is keeled-tabulate or bisulcate. On the larger phragmocone are many irregularly fasciculate ribs, some of which are inflated near the base marking the beginning of *Witchellia*-type bullae. The costation of the smaller specimen is much coarser but similar in style.

The body chambers of the two specimens were 52 mm and approximately 32 mm in respective complete diameters. The whorl section of the larger specimen is compressed elliptical with strong keel and rather shallow sulci on the internal mold. Somewhat convex blunt ribs are developed on the middle of the sides but become obsolete near the aperture. The shell remnants show increasingly convex growth striae and test thickening near the peristome. An incompletely preserved ventral lappet (or ? rostrum) is still bisulcate-tricarinate on the internal mold. The sides are somewhat constricted on the internal mold only and extend in small medio-lateral lappets which may be incomplete.

The body chamber fragment of the smaller specimen has strong rursiradiate ribs which are partly somewhat fasciculate. The externside is bisulcate throughout.

The septal suture is exactly as in juvenile *Witchellia sutneroides*, n. sp. E is narrow and moderately deep, the E/L saddle large, L large and deep, the umbilical lobes small and non-suspensive.

Comparison. — This form strongly resembles the English *P. (Spatulites) spatians* (Buckman) which has a diameter of 59 mm, and the smaller '*Maceratites*' *aurifer* Buckman (34 mm D); it is distinguished by the better developed bisulcate-bicarinate venter retained on the body chamber, the stronger ornate shoulders and probably the simplified costation of the body chamber.

Significantly, these same features distinguish the apparently corresponding macroconchiate *W. sutneroides*, n. sp. from the northwestern European *W. laeviuscula* - *W. sutneri* group.

<i>Measurements.</i> —	Dmm	W%	H%	U%
McM J 939 (aperture)	52	26	35.5	36.5
(phragm.)	35	c.27	c.39	34
McM J 1294 (body ch.)	c.32	—	—	—
(phragm.)	25	24	c.36	32

Family **OTOITIDAE** Mascke, 1907

[Incl. Sphaeroceratinae Buckman, 1920]

Otoitids and sphaeroceratids are regarded as two subfamilies of a single family by this author (Westermann, 1956, 1964, p. 55) in contrast to their treatment of the 'Treatise' (Arkell, *et al.* 1957). Schindewolf (1965, pp. 161-177) recently upheld their separation at the family level because of minute differences in the umbilical lobes. However, he retained unquestioned in his Otoitidae only the single probably dimorphic pair *Emileia* - *E. (Otoites)* after transfer of *Docidoceras* and *D. (Trilobiticeras)* to his Sphaeroceratidae. Schindewolf did not investigate the supposed hammatoceratid *Abbastites*, placed in *Erycites* in the Treatise but generically distinguished by the present author, which according to the evidence from Wide Bay is directly ancestral to *Docidoceras* (*Pseudocidoceras*), n. subgenus. Because of the presence of the secondary morphological internal lateral lobe U_n , *Abbastites* should be transferred from the Hildocerataceae to the Stephanocerataceae in accordance with Schindewolf's classification.

If the supposed dimorphic pair *Docidoceras* - *D. (Trilobiticeras)* is placed in the sphaeroceratids as supposed by Schindewolf, the distinction between the otoitids and sphaeroceratids is further diminished by neglecting differences in dimorphism; in the "old" classification only the otoitids possessed lappet bearing microconchs. The Tullitidae [and Pachyceratidae] are certainly more clearly distinct from the otoitids and sphaeroceratids than asserted by Schindewolf (1965, p. 235); for example, the septal suture lacks the U_n .

This author is most hesitant to follow Schindewolf (1965, p. 170) in placing the probable dimorphic pair *Cadomites* - *C. (Polyplectites)* in the sphaeroceratids because of their unusual septal structure (Westermann, 1956, p. 242) which he now confirmed. There can be little doubt about their direct descent from typical stephanoceratids.

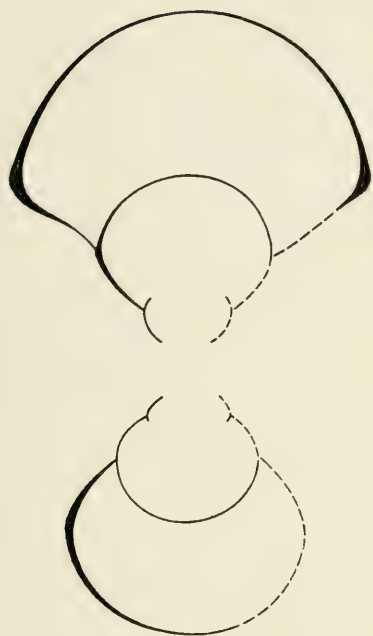
Pseudotoites Spath is characterized by planulate subcircular to rounded ovate inner whorls with inclined and partly smooth umbilical wall, 'cadicone' intermediate whorls, and typically ovate outer whorls bearing blunt nodes and bullae on the umbilical margin with reduced primaries (Text-fig. 42). Primaries and

secondaries are usually prosoradiate. The aperture is not collared and the peristome strongly oblique. The author gratefully received plastercasts of several Australian topotypes, identified by Arkell, from the Sedgwick Museum. The internal suture of *Pseudotoites*, as investigated in two specimens of *P. ex gr. P. singularis* (Gottsche) from the Argentine Andes, agrees in detail with that given for *Emileia* and *E. (Otoites)* by Schindewolf (1965, pp. 153, 162), probably including the two-pronged U_1 . However, the earliest growth stage could not be developed. Coiling and whorl section of *P. singularis* resemble closely the more evolute species of *Emileia*.

The common Alaskan "sub-coronates", formerly tentatively regarded as new subgenus of *Pseudotoites* (Westermann, 1964a, footnote 19, p. 61, pl. 9, figs. 1a, b), have throughout depressed subelliptical ('lenticular') whorls with mid-lateral edge, sharp long primaries, and an undivided U_1 lobe, and are, therefore, now classified under *Docidoceras* (*Pseudocidoceras*), n. subgen. *D. (Pseudocidoceras)* is distinguished from *Docidoceras s.s.* mainly in the regularly strong projected (convex) secondaries and in the oblique smooth aperture without collar.

The Australian '*Zemistephanus*' Arkell (1954), which is not identical with the Canadian stephanoceratid *Zemistephanus* (Imlay, 1964; Westermann, 1964b, pp. 61-64), somewhat resembles *D. (Pseudocidoceras)*. A plastercast of the septal surface of *Z. corona* (Arkell, 1954, pl. 39, fig. 3), kindly sent by the University of Western Australia, shows the bullate pattern of the Otoitidae (*s.l.*). However, the more striking similarities are with the South American *P. (?) sphaeroceroides* (Tornquist). Both the Australian and South American "coronates" may best be classified under a new subgenus of *Pseudotoites* (Westermann, 1964b, p. 53) although they may be related as closely to *Docidoceras*.

In spite of my recent extensive search in the type-area, no new material of *P. (?) sphaeroceroides* is available. The holotype was refigured by Arkell (1954, pl. 40, figs. 2a-c). The complete specimen of *P. (?) sphaeroceroides* previously figured (Westermann, 1964b, pl. 9, fig. 7) has strong tubercles (internal mold) on the body chamber which are lacking in *D. (Pseudocidoceras)*, and the whorl section of the phragmocone is depressed ovate with the

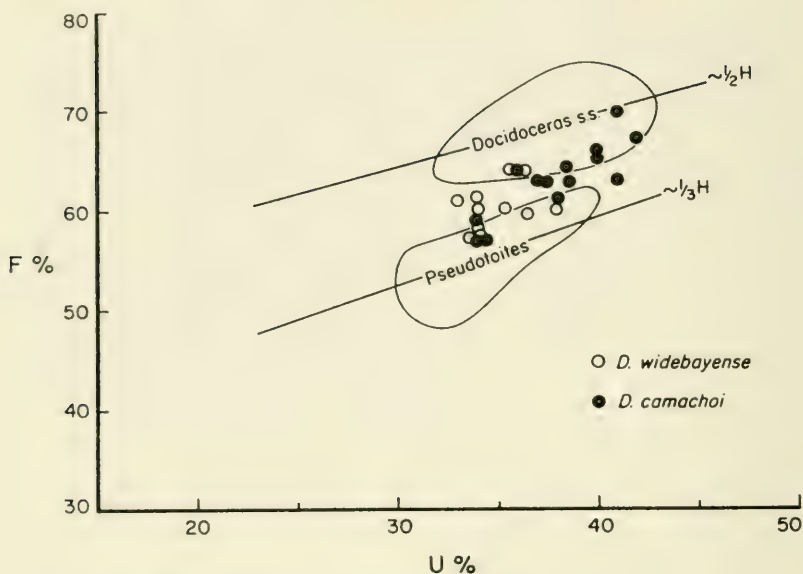


Text-fig. 42. — Cross-section of the inner and intermediate whorls of *Pseudotoites robiginosus* (Crick) [det. *P. emiliodes* by Arkell; Sedgewick Museum F 11923], Mount Hill, Western Australia; for comparison with the Alaskan species. Note the planulate and rounded inner whorls.

lateral edge at about two-fifths whorl-height, while it is usually depressed elliptical in the Wide Bay forms. However, the section of the inner whorls of the Australian *Z. corona* is apparently poorly known, except for the end of the phragmocone where it is also depressed ovate.

The material collected by Shell Oil Company, the U.S. Geological Survey, and by me from the *S. sowerbyi* Zone of Wide Bay in summer 1964, is evidence for two distinct but associate otoitid groups, i.e. subcoronate *Docidoceras* (*Pseudocidoceras*) and planulate *Pseudotoites*.

Thus, *Pseudotoites* is present in North America, but neither as formerly supposed (Arkell, 1954, p. 586) by '*Ammonites*' *carlottensis* Whiteaves from western British Columbia and southeastern Alaska which is a *Zemistephanus* (Imlay, 1964; Westermann, 1964b, footnote 19, p. 62), nor by the abundant "sub-coronate" Wide Bay forms as I suggested previously (*op. cit.*, pl. 9, fig. 1), but by the scarce planulate *P. cf. argentinus* Arkell and *P. cf. transatlanticus* (Tornquist) of the *S. sowerbyi* Zone of Wide Bay.



Text-fig. 43.—Scatter for relative flank width ($F:D \times 100$) and umbilical width ($U:D \times 100$) of *Docidoceras* (*Pseudocidoceras*) spp., adult phragmocones, with indicated corresponding areas for plot distributions of *Docidoceras* s.s. and *Pseudotoites* s.s. (from Westermann, 1964 b, abb. 12). This parameter reflects the 'ovateness' of the whorl section (approximate position of maximal whorl width or lateral edge with respect to whorl height indicated). Note that the Alaskan *D. (P.) widebayense*, n. sp. and *D. (P.) camachoii*, n. sp. are intermediate in whorl section ranging from subelliptical to markedly but not strongly subovate.

It appears that the Andean *Pseudotoites* and *P. (Latotoites)* have strong affinities in whorl-section and costation with the relatively evolute early representatives of the mainly European *Emileia* ('*Emileites*') and *E. (Otoites)*; in fact, they are morphologically intermediate between Australian *Pseudotoites* and northwestern European *E. (Emileites)*.

The phenomenon called reticulate variation and the consequent taxonomic dilemma is well represented in this world-wide group of Otoitidae (including Sphaeroceratinae). Local or regional morphological clusters can be delimited and may be attributed to species, but the distinction between genera breaks down because of lateral contiguity. 'Vertical' contiguity appears to be of minor importance because the respective faunas are probably penecontemporary.

The major clusters are (1) The European *Docidoceras* s.s., (2) the Alaskan *D. (Pseudocidoceras)*, (3) the South American *Pseudotoites* and (4) the Australo-Indonesian *Pseudotoites* [for West Irian, formerly West New Guinea, see Visser and Hermes, 1962, encl. 17, fig. 17, and for the Sula Islands, Moluccas, see Kruizinga, 1926, pl. 6, figs. 1, 2; pl. 12, fig. 3]; a fifth cluster could be represented by the northwestern European *Emileia* ('*Emileites*'). All clusters certainly overlap in time within the lower to middle *S. sowerbyi* Zone. Clusters (1) to (4) appear to be subcontiguous in morphoclinal relationship and geographic distribution, the Australo-Indonesian *Pseudotoites* being most distinct from the European *Docidoceras* s.s., and (2) and (3) successively occupying intermediate positions. Each cluster is distinguished by a combination of characters which also occur singly in the others. Yet in southern Alaska (2) and (4) are associated breaking the linear relationship. The South American *Pseudotoites singularis* (Gottsche) group appears to be as closely related to *E.* ('*Emileites*') as to (1) *Docidoceras* s.s., both essentially European. Besides the major clusters, supplementary clusters with different lateral distributions occur; *Pseudotoites argentinus* Arkell from the South American cluster supplements the Alaskan cluster, the cadicone *P.* (?) (n. subgen.) *sphaerocerooides* (Tornquist) group supplements the South American and probably also the Australo-Indonesian clusters. These forms are, in turn, closely affiliated with the Alaskan main cluster of *D. (Pseudocidoceras)*. It is possible that even the European *E.* ('*Emileites*') cluster was spread as far as South America.

Genus **DOCIDOCERAS** Buckman, 1919

Type species by original designation. — *D. cylindroides*, Buckman, 1919, from the *S. sowerbyi* Zone, *L. discites* Subzone, of southern England and France.

The taxonomy of the genus has recently been discussed by this author (1964b, pp. 51, 56-57). The nominate subgenus *D. (Docidoceras)* is macroconchiate and includes the three distinct species *D. cylindroides* Buckman, *D. planulatum* Buckman, and *D. longalvum* (Vacek); probably synonymous with, or subspecies of these are '*Coeloceras*' *limatum* Pompecki, *D. perfectum* Buckman, *D. biforme* Buckman, and *D. liebi* Maubeuge. All have simple moderately

oblique and typically collared peristomes. The probably corresponding microconchiate forms are included in the subgenus *D. (Trilobiticerus)* with the only distinct named species *D. (T.) punctum* (Vacek) which includes as subspecies or synonyms *T. trilobitoides* Buckman and *T. platygaster* Buckman [part.]; the aperture bears lateral lappets.

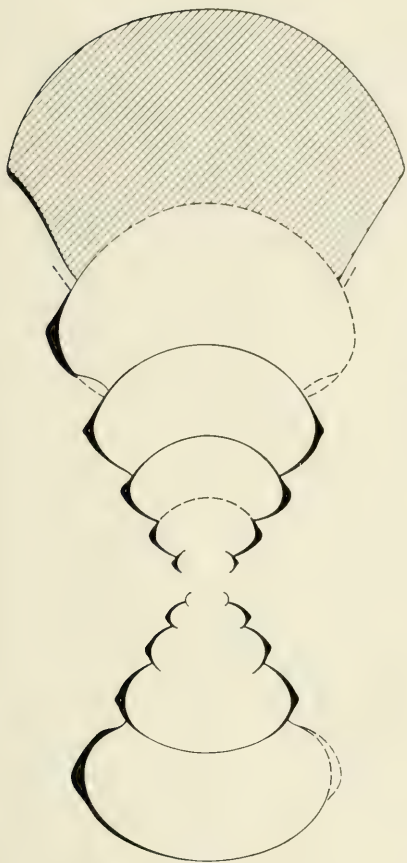
The pertinent feature distinguishing *Docidoceras* from other Otoitidae [including Sphaeroceratinae] is the evolute, strongly depressed 'lenticular' whorl section with mid-lateral edge. Other Otoitidae have ovate whorl sections with the maximal whorl width or lateral-edge below mid-flank (less than one-half whorl height) (Text-fig. 43). The 'coronate' whorls of *Docidoceras* commence at only a few millimeters diameter and are developed throughout the phragmocone, although the adult phragmocone and particularly the body chamber may become somewhat ovate by inflation of the externside and steepening of the inner flanks (umbilical slope). As in most other Otoitidae the costation of typical *Docidoceras* is more or less rectiradiate, crossing straight over the externside, but there are some exceptions such as the holotype of *D. liebi* Maubeuge [? = *D. planulatum* Buckman]. Unrefuted *D. (Docidoceras)* and *D. (Trilobiticerus)* are known from the northwestern European and Mediterranean provinces only.

Subgenus **DOCIDOCERAS (DOCIDOCERAS)** Buckman, 1919

Docidoceras (Docidoceras?) sp. aff. *D. longalvum* (Vacek) 1886 Pl. 32,
fig. 5a-c; Pl. 33; Text-fig. 44

Material. — One large phragmocone with incomplete body chamber, well-preserved internal mold, from WA 10 at 8 m (McM J 937). Lower *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, upper Kialagvik Formation, Wide Bay.

Description. — The shell is typically "serpenticone planulate"; the whorls are strongly depressed elliptical, partly slightly ovate in section with rounded lateral edge, and become increasingly more evolute, embracing the preceding whorls less than one-third. The costation is prominent on the phragmocone consisting of straight rectiradiate primaries which trifurcate in mid-lateral tubercles or nodes into slightly prosoradiate secondaries. The secondaries become more densely spaced and blunt on the end of the phragmocone. The preserved one-fourth whorl of the body chamber is almost smooth.



Text-fig. 44. — Cross-section of *Docidoceras* (*Docidoceras*) sp. aff. *D. longalvum* (Vacek), complete specimen with strong umbolateral groove on last phragmocone whorl and body chamber, loc. WA 10 in the lower *Pseudocidoceras* zonule (McM J 937); $\times 1$.

The ultimate one-quarter whorl of the phragmocone and especially the body chamber fragment have on right and left innermost flanks (umbilical slopes) strong and well-defined grooves [here named umbolateral groove]. On the phragmocone these are largely filled with "porous material" which is believed to represent secondary secretion, possibly originally rich in organic material, for attachment of the paired retractor muscle (see also Jordan, 1968). On the body chamber, the grooves correspond to all of the inner flanks and are bordered by a sharp mid-lateral edge (on the left side apparently raised by fracture) (Text-fig. 44).

The septum is typically bullate with slightly stronger outer than inner saddle axes. The suture is of moderate complexity with suspensive umbilical elements.

Discussion.—The Alpine holotype of *D. (D) longalvum* has recently been refigured (Westermann, 1964b, pl. 6, fig. 1). The English *D. perfectum* Buckman was drawn into synonymy (*op. cit.*, p. 52; Bremer, 1966, p. 163) matching the holotype of *D. longalvum* except for the slightly stronger costation.

The Wide Bay specimen is distinguished from *D. longalvum* by the more distant partly prosoradiate and markedly stronger costation and by the umbolateral groove of unknown taxonomic significance, features which suggest affiliation with *D. (Pseudocidoceras)*.

Measurements.—

	Dmm	W%	H%	U%	P	S
McM J 937 (body ch.)	140	39	c.26	c.55	—	—
(phragm.)	96	47	c.27	51	15	52
"	65	51	27	48	13.5	39

Subgenus **DOCIDOCERAS (PSEUDOCIDOCERAS)** Westermann,
n. subgen.

Type species by original designation.—*D. (P.) widebayense*, n. sp. from the *S. sowerbyi* Zone of Wide Bay.

Subgenus diagnosis.—A subgenus of *Docidoceras* with strongly prosoradiate costae (secondaries therefore ventrally convex) and strongly oblique smooth peristome; whorl section may be weakly ovate.

Discussion.—Although prosoradiate costae with convex secondaries are also known to occur rarely in European *D. (Docidoceras)* [*D. liebi*], Alaskan forms certainly display this feature more strongly and with great regularity. Toward the end of the phragmocone, the secondaries may medially be gently interrupted and even alternating. However, this feature is never continuous over several whorls and not regarded as significant. While the peristome of the Alaskan specimens is smooth, simple, and strongly oblique, most of the European *D. (Docidoceras)* have a less oblique peristome with collar. The primaries of the body chamber tend to develop into bullae. The whorl section varies from lenticular to markedly ovate with a corresponding position of the lateral edge from one-half to three-sevenths, rarely to two-fifths whorl height. These features more or less resemble those of *Pseudotoites* which

is distinguished by planulate rounded inner whorls, short primaries which may become obsolescent, and prominent lateral nodes or bullae of the outer whorl.

A single apparently corresponding microconch was associated with the several abundant macroconchiate *D. (Pseudocidoceras)* species. Just like the macroconchs from *Docidoceras s.s.*, the phragmocone is distinguished from *D. (Trilobiticeras)* in the strongly prosoradiate ribs. The naming of a new subgenus would be premature and could later become superfluous, if dimorphism can be established as more material becomes available.

The affinity of *D. (Pseudocidoceras) camachoi*, n. sp. to *Abbasites platystomus* Westermann (1964a, pl. 66, figs. 1-2) of the subadjacent *E. howelli* Zone is so striking that their direct phyletic relationship appears certain. *A. platystomus* is distinguished only in the reduced E/L saddle and in the alternating secondaries of the inner whorls.

D. (Pseudocidoceras) bears much resemblance to the 'Emileites' group, i.e. widely umbilicate *Emileia* species from the middle and upper *S. sowerbyi* Zone of southern England, especially to *Emileia crater* Buckman; these in turn, may have evolved directly from *D. cylindroides* Buckman of the lower *S. sowerbyi* Zone (Westermann, 1946b, p. 60). The 'Emileites' group needs reinvestigation; it is distinguished from the Alaskan forms by the ovate rounded whorl section and the retaining of long, thin primaries on the body chamber.

Docidoceras (*Pseudocidoceras*) widebayense Westermann, n. sp.
Pls. 34-37; Text-figs. 45-49

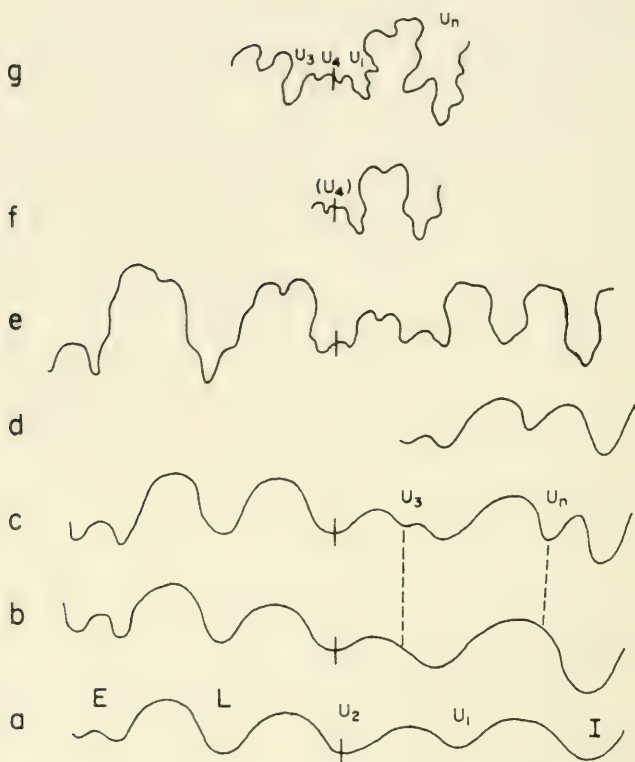
Holotype. — Pl. 34, fig. 1a-d; a well-preserved complete internal mold with minor test remains. Repository: U.S. Nat. Museum, No. 160249.

Locus typicus. — Sea cliff on southeastern shore of Wide Bay, 8.5 km (5.32 mi.) south, $46\frac{1}{2}^{\circ}$ west of west end of Hartman Island. U.S. Geological Survey Mesozoic locality 21251 (collector Imlay and Miller, 1948).

Stratum typicum. — *Pseudocidoceras* zonule, supposedly about 160 m below top of Kialagvik Formation.

Derivatio nominis. — Named after the occurrence at Wide Bay.

Age and occurrence. — *S. sowerbyi* Zone. Bajocian. Common

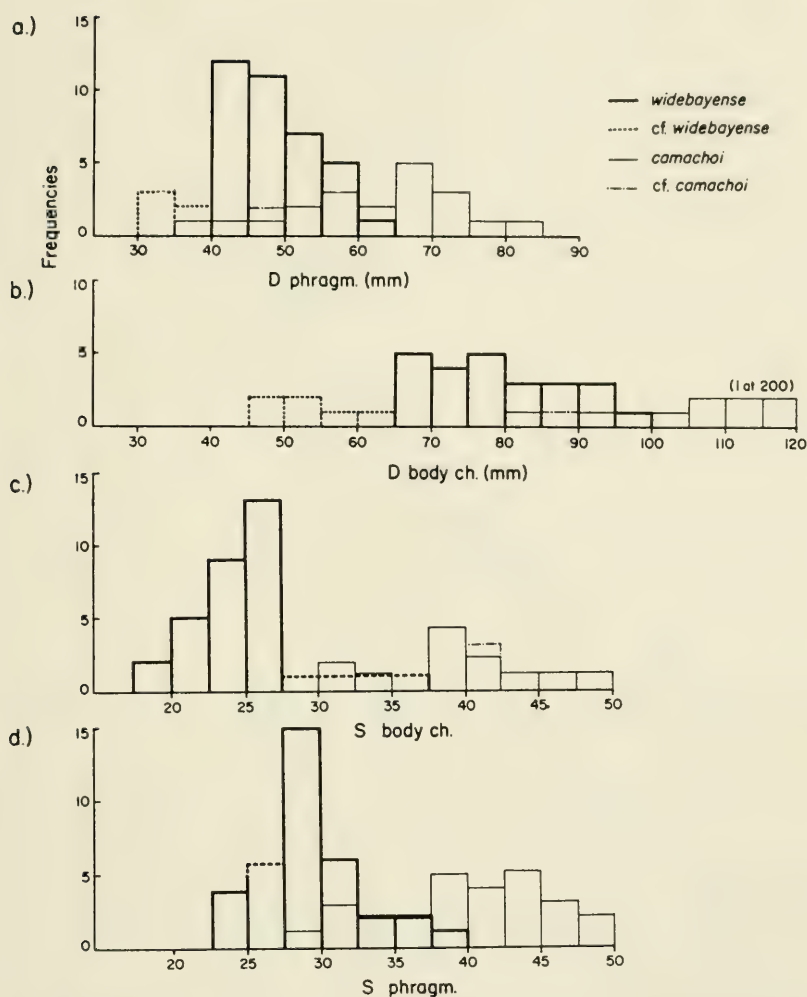


Text-fig. 45 a-g. — Septal sutures of *Docidoceras* (*Pseudocidoceras*), n. subgen., loc. USGS 19862 in the *Pseudocidoceras* zonule of Wide Bay, magnified. a-f. *D. (Pseudocidoceras)* sp. indet. juv.; a-b. at c.1 mm W, c. at 11.6 mm W and 1 mm H, d. at c.2 mm W, e. at 3 mm W and 2 mm H, f. at 4 mm W and 2.5 mm H; g. *D. (P.) widebayense*, n. sp. at 6 mm W, 4 mm H and c.9 mm D. Note the secondary lobe U_n .

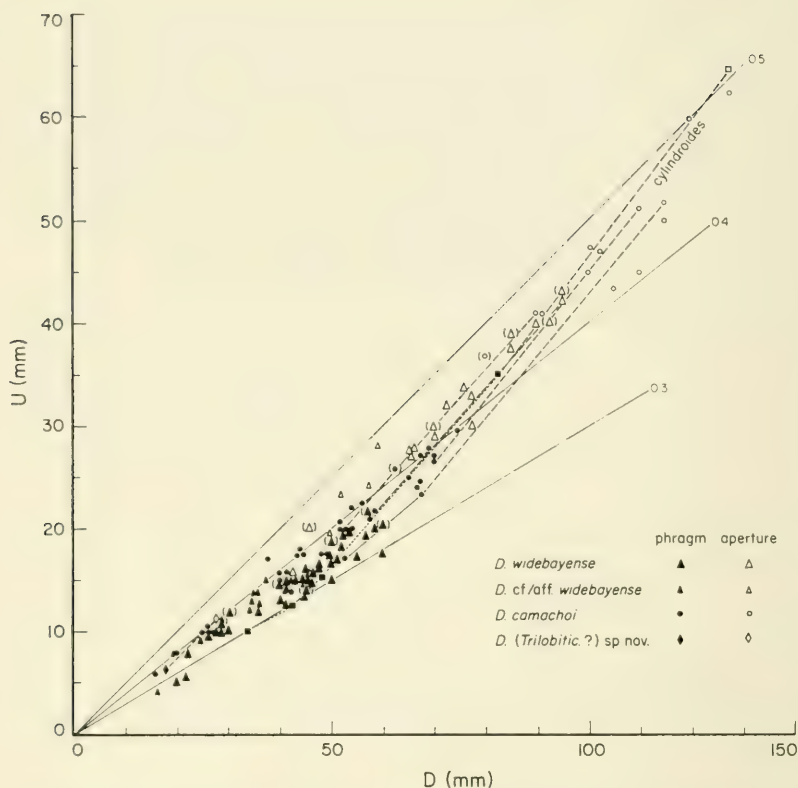
in the *Pseudocidoceras* zonule, especially in the upper part, rare in the subjacent *E. amplexens* zonule; only known from the southeastern side of Wide Bay.

Diagnosis. — A medium-sized species of *D. (Pseudocidoceras)*, strongly costate including body chamber.

Material. — Three complete and two incomplete specimens from USGS 12405; one almost complete specimen and one phragmocone from USGS 19801; one complete specimen, five phragmo-

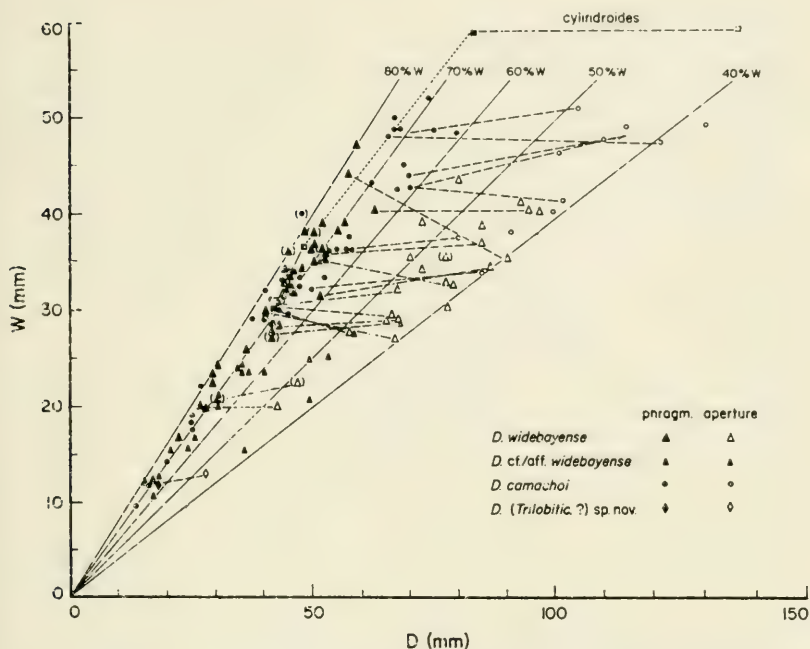


Text-fig. 46 a-d. — Frequency histograms for diameter (D) and secondaries per halfwhorl (S) of *Docidoceras* (*Pseudocidoceras*), n. spp., *Pseudocidoceras* zonule of Wide Bay, Alaska. a-b. Note that *D. (P.) widebayense*, n. sp. is usually smaller than *D. (P.) camachoi*, n. sp., but there is much overlap. c-d. Note that *D. (P.) widebayense* bears fewer, i.e. stronger, secondaries than *D. (P.) camachoi* and that bimodality is certainly significant for body chambers.



Text-fig. 47.—Scatter with several growth lines for relative umbilical width (U:D) of *Docidoceras* (*Pseudocidoceras*), n. spp. and *D. (Trilobiticeras?)* sp. indet. *Pseudocidoceras* zonule of Wide Bay; Holotype of the type species *D. cylindroides* Buckman included for comparison (phragmocones: solid lines, body chambers: dashed lines). Note that the growth lines remain essentially constant throughout the phragmocone but increase with the body chamber, that *D. (P.) widebayense*, n. sp. tends to be slightly more evolute than *D. (P.) camacho*, n. sp., that the microconchiate *D. (Trilobiticeras?)* plots subcentrally within the former macroconchiate forms, and that *D. (D.) cylindroides* resembles *D. (P.) widebayense* in this parameter.

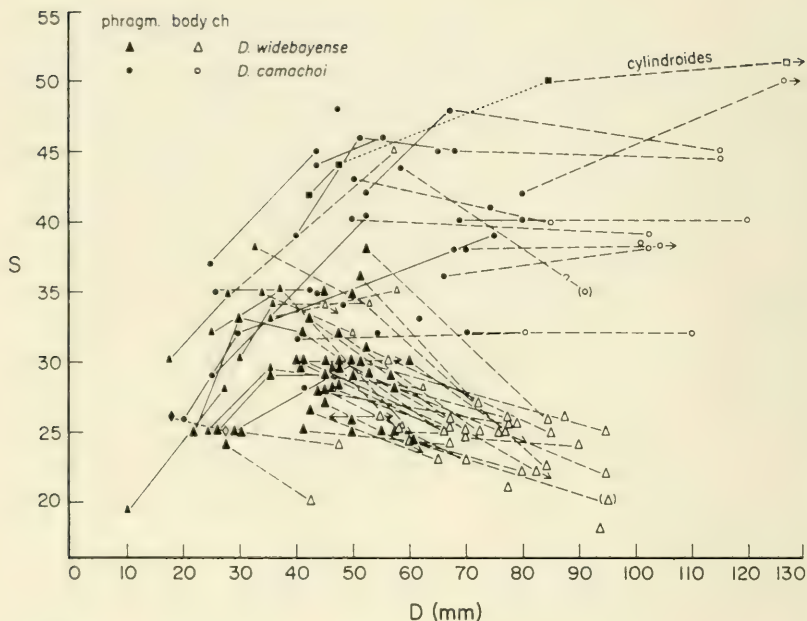
cones partly with incomplete body chamber and several fragments from the USGS 19862 (USNM 160250); several complete phragmocones and one body chamber from USGS 19869; two complete specimens, one phragmocone, several fragments of phragmocones and body chambers from USGS 21251; one body chamber with phragmocone fragment from WA 5; (?) one small specimen with



Text-fig. 48. — Scatter with growth lines for relative whorl width ('thickness' = $W:D$) of *Docidoceras* (*Pseudocidoceras*), n. spp. and *D. (Trilobiticeras ?)*, n. sp. indet., *Pseudocidoceras* zonule of Wide Bay (same symbols as Text-fig. 47). Note that width growth ceases or even decreases (growth rate becomes negative) at the beginning of the body chambers which, therefore, become relatively 'thinner', that there is close resemblance between *D. (P.) widebayense*, n. sp. and *D. (P.) camachoii*, n. sp., and that the microconchiate *D. (Trilobiticeras ?)* as well as the holotype of the generic type species *D. cylindroides* Buckman plot within the distribution of the macroconchs.

aperture from WA 10 at 6 m; six almost complete internal molds and several fragmentary phragmocones and body chambers from WA 10 at 1 to 22 m (McM J 903, 909-917); two incomplete phragmocones with body chambers, several large fragments from WA 11 at 19 to 27 m (McM J 904-906); two complete internal molds with test remains, two phragmocones, five fragments from WA 13 at 9 to 16 m (McM J 895-902, 916). All except one [WA5 = *E. amplexens* zonule] from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description. — The phragmocone is 'sub-coronate' throughout. Already at 6-8 mm diameter, the evolute whorls are strongly de-



Text-fig. 49.—Scatter with growth lines for density of secondaries (number per halfwhorl) vs. diameter (S:D) for *Docidoceras* (*Pseudocidoceras*), n. spp. and *D. (Trilobiticeras ?)*, n. sp. indet., *Pseudocidoceras* zonule of Wide Bay (same symbols as Text-fig. 47). Note that there is large overlap for the phragmocones of *D. (P.) widebayense*, n. sp. and *D. (P.) camacho*, n. sp., but clear separation for the body chambers, that *D. (Trilobiticeras ?)* sp. plots within the distribution of the macroconchiate *D. (Pseudocidoceras)*, and that the holotype of the type species *D. (D.) cylindroides* Buckman resembles *D. (P.) camacho* in this parameter.

pressed, lenticular, about double as wide as high, with evenly rounded broad externside, distinct circa-median lateral edge and rounded inner flanks which reach the umbilical seam almost vertically. Prosoradiate primaries extend from the umbilical seam up to the lateral edge where they carry small nodes. The densely spaced secondaries project strongly and cross convexly, sometimes with median weakening, over the broad externside.

The morphogeny is well known beyond 15 mm diameter. As shown in the scatter diagrams (Text-figs. 47, 48), there is little change in the growth rate for whorl shape and coiling up to the end of the phragmocone. Whorl width varies from 64 to 82 percent

of the diameter and the whorl height approximates one-half of the width. The lateral edge (or the maximal whorl width) lies between three-sevenths, more rarely two-fifths, and one-half whorl height, *i.e.* just below the middle of the flank. The umbilical width ranges from 28 to 38 percent of the diameter. The diameter of the adult phragmocone varies greatly with strong positive skewness, ranging from probably less than 40 (?30) to more than 60 mm, and measuring most commonly 40-50 mm (Text-fig. 46).

There are 10-14 rectiradiate to moderately prosoradiate primaries per halfwhorl on the intermediate and outer whorls of the phragmocone. They arise at the umbilical seam and strengthen gradually up to the lateral edge where they carry nodes. Here they bifurcate or trifurcate into always more or less strongly prosoradiate secondaries which usually curve evenly convex over the extern-side, but are sometimes slightly arched or become medially obsolete. The density of secondaries on the last one or two whorls of the phragmocone varies from 25 to 38 per halfwhorl, being most commonly 25-30 (Text-fig. 49).

The adult body chamber is from three-quarters whorls to over one whorl in length and varies in diameter from probably 45 to 100 mm, measuring most commonly 65-85 mm (Text-fig. 46). From the beginning of the body chamber, the coiling becomes markedly more evolute (39-47%). Whorl width ceases to increase and there may be slight 'contraction'. Consequently the whorl section becomes higher and, by reduction of the lateral edge, rounded elliptical to slightly ovate (Text-figs. 47, 48). At the aperture, the test is internally greatly thickened causing a broad oblique constriction on the internal mold, and a broad lip or ventral lappet produces a strongly oblique peristome.

The costation of the body chamber is most distinctive for this species, consisting of increasingly strong and distant primaries and especially heavy, strongly prosoradiate secondaries (18-27 per halfwhorl) (Text-fig. 49). The primaries do not markedly retract from the umbilical seam; they retain greatest prominence over the maximal whorl width where they often carry blunt nodes.

The septum is typically bullate (abullate), with central E-I lobe axis and complete L-U_n lobe axis separating two sub-equal saddle axes (E/L-I/U_n and L/U₂-U_n/U). The septum of the re-

lated *D. camachoi* n. sp. has recently been figured under '*Pseudotoites*, n. sp.' (Westermann, 1964b, pl. 9, fig. 1a, b).

The septal suture (Text-fig. 45) is superficially similar to most Otoitidae (including Sphaeroceratinae) and other Middle Jurassic sphaerocone and cadicone ammonites, with two subequal morphological external and internal saddles and more or less high complexity. The morphogeny observed in a *D. widebayense* (Text-fig. 45g) agrees in detail with that of a nucleus of *D. (Pseudocidoceras)* sp. indet. from the same locality, so that only the umbilical elements at 10 mm diameter have been figured of the former in supplementation of the other series (Text-figs. 45 a-f). Up to 1 mm whorl width, only E, L, U₂, U₁ and I are present with the umbilical seam situated on the lower inner slope of the U₂/U₁ saddle. At 1.2 - 1.5 mm W (0.8 - 1 mm H), U₃ develops externally adjacent to the seam and, simultaneously, on the dorsal side of the crest of the U₁/I (internal) saddle. Frilling of the suture commences at about 2.5 mm W (1.5 mm H), when U_n has developed to a large straight lobe separating the sub-equal U₁/U_n and U_n/I saddles, while U₁ remains undivided. U₄ develops adjacent to the seam at about 4 mm whorl width (2.5 mm H and 6 mm D), at a stage when all other lobes including U₁ are trifid. The shape of some lobes, especially of U₂, is often strongly asymmetric tending to appear bifid. Only a moderate degree of complexity by frilling is achieved and the lobes remain usually quite broad, in contrast to *Emileia*.

Comparison. — The quantitative studies of *D. widebayense* and *D. camachoi* establish clearly discontinuous variation of the body chamber costation which in this species is always much stronger than in *D. camachoi* (Text-fig. 49). *D. camachoi* is usually (20-30% overlap) slightly more involute and finer costate throughout (Text-figs. 47, 49). *D. widebayense* and *D. camachoi* are associated in the lower part of the *Pseudocidoceras* zonule to which *D. camachoi* appears to be restricted.

Measurements. —

[*F: flank width, the diameter of the lateral edge]

	Dmm	W%	H%	U%	F%*	P	S
Holotype (apert.)	70	50	30	41.5	—	10	23
(phragm.)	45	73	36	36	64	12	28
Loc. USGS 12405 (apert.)	94	42.5	25.5	45	—	12	25
(phragm.)	51	c.70	c.37	33.5	—	13	c.30
"	c.29	c.80	c.40	c.36	—	13.5	c.25
" (apert.)	76	42	26.5	45	—	11	25
(phragm.)	c.48	—	—	—	—	12	c.30
" (c. apert.)	70	—	—	—	—	12.5	c.25
(phragm.)	45	76	36	32.5	—	13	c.28
" (apert.)	c.88	—	—	—	—	c.11	c.26
(phragm.)	50	70	36	33	—	12	c.30
" (phragm.)	43	78	35	41	—	13	35
Loc. USGS 19801 (apert.)	78	c.45	c.28	42	—	11	26
(phragm.)	c.50	c.74	c.36	c.35	—	13	c.29
(phragm.)	48	80	37.5	34.6	—	13	c.30
USNM 160250 (apert.)	90	39	26.5	44.5	—	11	24
(phragm.)	58	76	36	38	—	c.12	c.25
Loc. USGS 19862 (c. apert.)	c.67	c.48	c.34	c.42	—	c.12	25
(phragm.)	41	73	40	30.5	—	13.5	c.32
"	30	80	43	33.5	—	c.13	c.33
"	22	75	41	36	—	12	c.25
" (apert.)	c.85	c.46	c.27	c.46	—	c.13	c.26
(phragm.)	c.52/c.40	c.74	c.35	c.37	—	c.14	c.37
" (body ch.)	55	c.66	c.35	34.5	—	13	26
(phragm.)	x.48/29	79	34.5	34.5	—	13	c.25
"	15	80	40	33	—	12	—
" (phragm.)	45	71	36	33	—	13	29
"	36	71	38	33.5	—	13	c.29
"	26.5	75	40	36	—	13	c.25
"	16	75	34.5	35	—	c.12	—
Loc. USGS 21251 (apert.)	c.80	c.54	c.30	—	—	c.11	c.22
(phragm.)	55	c.69	42	31	—	c.12	c.25
" (apert.)	c.70	—	—	c.43	—	11	25
(phragm.)	42	67	36	36	64	14	33
" (apert.)	78	38.5	31	—	—	c.11	c.21
(apert.)	93	44	28	c.43	—	c.11	c.18
Loc. USGS 19801 (phragm.)	c.50	c.76	c.38	c.34	—	c.13	c.25
" (body ch.)	78	—	—	34.5	—	11	25
(phragm.)	60	—	—	29.5	—	12.5	c.30
" (phragm.)	46	70	36	34	58.5	14	29.5
McM J909 (body ch.)	c.80	—	—	—	—	—	c.22
(phragm.)	52	75	31	38.5	—	c.13	c.29
Loc. WA 10 (phragm.)	48	71	33	33.5	—	12.5	c.28
Loc. WA 10 (c. apert.)	66	41	27	42.5	—	12	25
(phragm.)	c.41	c.66	c.34	c.35	—	13.5	30
McM J911 (body ch.)	60	58	38.5	47.5	—	12	24
(phragm.)	44	75	34	c.32	—	c.12	c.27
McM J912 (phragm.)	44	77	40	33	61	14	35
McM J917 (apert.)	72	47.5	29	44.5	—	c.12	c.25
(phragm.)	46	74	37	34	57	12	32

		Dmm	W%	H%	U%	F%*	P	S
McM J914	(apert.)	85	43.5	26	c.46	—	c.13	c.25
	(phragm.)	52	69	c.35	38	60	14	31
McM J915	(apert.)	c.95	c.50	c.31	—	—	—	(20-25)
	(phragm.)	c.59	80	37	34	—	10	28
McM J903	(apert.)	78	42	29.5	38.5	—	11	25.5
	(phragm.)	(c.44)	c.82	c.43	31	—	11.5	c.28
McM J905	(apert.)	c.72	c.54	c.34	—	—	c.12	(c.27)
	(phragm.)	52	67.5	33	36	—	14.5	36
McM J904	(apert.)	84	39	26	44	—	11	22.5
	(phragm.)	50	62	33	c.38	—	12.5	c.35
McM J906	(body ch.)	c.65	c.45	c.26	c.26	—	c.12	c.23
	(phragm.)	42	71	35.5	35.5	60	11	26.5
McM J895	(apert.)	78	—	—	—	—	11	26
	(phragm.)	c.44	c.75	c.36.5	c.34	60	c.12	c.30
McM J896	(apert.)	66	44	29	42	—	13	26
	(phragm.)	41	66	34	36.5	59.5	14	30
McM J897	(apert.)	66	40	29	42	—	10.5	24
	(phragm.)	41	70	35	34	57.5	11	25
McM J899	(phragm.)	57	68.5	33.5	34	61	11	29
McM J902	(phragm.)	50	72	38	30	—	c.12	26
McM J916	(apert.)	c.95	c.42	c.26.5	c.45	—	c.11	c.20
	(phragm.)	60	67	33.5	c.35	—	10.5	c.24

Docidoceras (Pseudocidoceras) cf. *D. widebayense*, n. sp.

Pl. 37,
figs. 1-5.

Material. — One almost complete somewhat distorted body chamber from USGS 19801 (USNM 160254); one complete specimen with distorted body chamber from USGS 19862 (USNM 160253); one in same preservation from USGS 21251 (USNM 160255); one body chamber from WA 10 at 14-16 m (McM J 931); one poorly preserved last whorl from WA 11 at 20 m (McM J 929); one almost complete internal mold from WA 13 at 12-15 m (McM J 927).

The recorded six specimens are distinguished from *D. widebayense* by smaller diameter (50-60 mm) and finer costation of the body chamber. This difference could perhaps be explained with 'stunting,' the small body chamber retaining the denser costation of the phragmocone of the 'normal' *D. widebayense* with which it agrees in size. When the diameters for phragmocone and body chamber are plotted in the frequency distribution for *D. (Pseudocidoceras)* they tend to 'normalize' the distribution for *D. widebayense* (Text-fig. 46).

Measurements. —		Dmm	W%	H%	U%	F%*	P	S
USNM 160254	(apert.)	c.58	—	—	—	—	15.5	35
	(phragm.)	36	64	36	35	—	17	34
	"	20	75	35	40	—	13	30
USNM 160253	(apert.)	52	48	28	44	—	16	34
	(phragm.)	33	67	35	36.5	63	16.5	c.38
	"	c.23	—	—	—	—	14	—
USNM 160255	(apert.)	c.62	—	—	—	—	—	c.28
	(phragm.)	c.35	c.68	c.34	c.40	—	16.5	c.29
	"	24	64.5	33	37.5	—	16	c.25
McM J927	(c. apert.)	44	53	32	42	—	13	34
	(phragm.)	34	69	34	37	—	14.5	33
McM J929	(c. apert.)	50	—	—	—	—	12	c.28
McM J931	(apert.)	50	47	31	39	—	14.5	32
	(phragm.)	34	70	35	—	—	c.18	c.35

Docidoceras (Pseudocidoceras ?) sp. aff. *D. widebayense*, n. sp. Pl. 36, figs. 2a, b and 3

Material. — Two slightly damaged almost complete internal molds from scree (McM J 932) and at 16 m of WA 10; at least the first one was associated with *D. widebayense*.

Both specimens are obviously fully mature at 42-46 mm diameter; this is about one-half of the mean diameter for *D. widebayense* which they otherwise strongly resemble. They are distinguished from the small *D. cf. widebayense* described above by the coarse secondaries of the body chamber. The lateral protrusion at the incomplete peristome of specimen J932 could be the base of a lappet; however, this could also be the fractured margin of a broad lip. The aperture of specimen J933 was probably simple. Since unusually coarse costation lies within the range of variation for *D. widebayense*, these two specimens are best classified as extreme variants of that species.

Measurements. —		Dmm	W%	H%	U%	F%	P	S
McM J932	(apert.)	46	46.5	32.5	45	—	12	23
	(phragm.)	30	70	33	40	—	12	c.25
McM J933	(apert.)	42	c.48	c.26	37	—	c.10	20
	(phragm.)	28	71	35.5	36	—	10.5	c.24

Docidoceras (Pseudocidoceras) camachoi Westermann, n. sp. Pls. 38-42; Text-figs. 46-49

Holotype. — Pl. 38, figs. a-c; a perfect internal mold with test remains.

Repository. — USNM 160256.

Locus typicus. — Sea cliff on southeastern shore of Wide Bay, probably U.S. Geology Survey Mesozoic locality 19862.

Stratum typicum. — Shales of the upper Kialagvik Formation, probably lower *Pseudocidoceras* zonule.

Derivatio nominis. — In honour of Horacio Camacho, Inst. Geologia, Universidad de Buenos Aires, Argentina.

Age and occurrence. — *S. sowerbyi* Zone, Bajocian, along southeastern side of Wide Bay; common in and possibly restricted to the lower part of the *Pseudocidoceras* zonule.

Diagnosis. — A large species of *D.* (*Pseudocidoceras*) with fine costae becoming obsolete on body chamber.

Material. — Two almost complete internal molds, two phragmocones and one complete body chamber from USGS 21251 (USNM 160259); one complete internal mold from USGS 19801 (USNM 160257); one complete specimen with damaged body chamber, largely with test, from USGS 19863; (? the holotype and) one large body chamber from USGS 19862; two well preserved, one poorly preserved and one incomplete internal mold and ? one almost complete specimen from USGS 12405; two almost complete internal molds and one plastercast from CAS 29011 (CAS 13111); three almost complete internal molds, two body chambers, three fragmentary phragmocones and ? one complete somewhat crushed internal mold with test remains from WA 10 at 2-8 m (McM J 918-921, 923, 925, 926); one phragmocone and one fragment from scree of WA 11 (McM J 924); one damaged phragmocone with body chamber from WA 13w (McM J 922). All from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

Description and comparison with D. widebayense, n. sp. — The phragmocone is "sub-coronate" and the whorl section strongly depressed lenticular with quasi-midlateral edge throughout, similar to *D. widebayense, n. sp.* (Text-figs. 46-48). However, the umbilicus is usually somewhat larger, varying from 35 to 48% of the diameter, and the costation somewhat finer and denser, with 12 to 17 primaries and (28) 31 to 48 secondaries (>25 mm D) per halfwhorl. Yet there is considerable overlap with *D. widebayense* in all these characters. The mature phragmocone is usually 55 to 80 mm in

diameter with an observed range from 40 to 85 mm, as compared to the commonly smaller phragmocone diameter of *D. widebayense* (40-60 mm D).

The body chamber becomes markedly more evolute while the (absolute) whorl width remains approximately constant; the adult diameter is most commonly 100-115 mm (*vs.* 65-80 mm D. in *widebayense*) with an observed range from 80 to 140 mm.

The costation weakens on the adult body chamber, in contrast to *D. widebayense* (Text-fig. 49). The primaries are somewhat denser (11-18 per half-whorl *vs.* 10-13) and usually become very blunt, often developing into oblique bullae which at least on the internal mold tend to retract from the umbilical seam. Yet some specimens become almost "coronate." The secondaries of the body chamber are extremely fine and dense, (32) 38-50 per half-whorl [*vs.* 18-27 (35?) in *D. widebayense*], and may become obsolete especially ventrally. As in all *D.* (*Pseudocidoceras*), primaries and secondaries are strongly prosocline and the secondaries cross the externside either evenly convex or somewhat arched.

The section of more or less the last whorl usually becomes slightly to markedly ovate, with the rounded lateral edge moving below mid-flank. The steepness of the inner flank and umbilical slope (or umbilical slope) is increased on the lateral mold, especially if the commonly present umbolateral groove is developed adjacent to the umbilical seam (Pl. 39; Pl. 40 fig. 1a). This groove is interpreted as the mold of a porous secondary shell layer, possibly originally with much organic substance, facilitating the better attachment of the retractor muscles (see also Jordan, 1968).

Septum and suture are identical with *D. widebayense*.

Discussion. — The differences of the often associated *D. widebayense* were given above; however, phragmocones, especially when incomplete, cannot always be identified specifically. *D. camachoi* bears much resemblance to *Docidoceras* (*Docidoceras*) *cylindroides* Buckman, type species of the genus, which is distinguished in the rectiradiate to weakly prosoradiate ribs and in the less oblique and collared peristome.

Measurements. —

[*F: flank width, the diameter of the lateral edge]

		D	W%	H%	U%	F%*	P	S
Holotype	(apert.)	100	40	27	45	—	13	38
	(phragm.)	58	65	36	36	64	15	40
Loc. USGS 12405	(phragm.)	67	72	37.5	34	(57)	13	45
	"	c.48	c.83	c.42	c.36	—	13	—
USNM 160258	(phragm.)	56	64	34	40	66	17	46
	"	44	67	31	40	—	15	44
Loc. USGS 12405	(phragm.)	64/48	69	c.33	—	—	c.15	48
	(phragm.)	43	72	34	42	—	17	c.45
	"	25	74	38	40	—	15	(35-40)
Loc. USGS 12405	(body ch.)	56	c.48	31	41	—	13	c.30
	(phragm.)	40	75	37.5	32.5	—	13.5	c.30
USNM 106257	(apert.)	110	42	25.5	46.5	—	11	32
	(phragm.)	c.70	c.63	c.30	c.38	—	11-12	c.32
	"	55	69	33	40	—	14	—
Loc. USGS 19862	(body ch.)	200/135	36	24.5	47	—	12	c.50 obsol.
	(phragm.)	80	60	c.28	—	—	c.11	c.42
Loc. USGS 19863	(apert.)	91	42	31.5	45	—	—	(c.35)
	(phragm.)	58	62	33	37	63	13-14	44
USNM 160259	(apert.)	115	42.5	30	44	—	c.15	c.45 obsol.
	(phragm.)	68	63	34	34	59	15	48
	"	52	69	36.5	33	—	15	—
Loc. USGS 21251	(apert.)	105	48.5	31.5	41	—	12	38
	(phragm.)	66	72	38	38	—	c.13	c.36
"	(apert.)	101	46	27	48	—	15.5	c.38
	(phragm.)	c.67	c.72	c.34	c.36	—	c.15	c.38
	"	40	80	34	38	61	12.5	—
"	(phragm.)	c.62	c.70	c.32	c.42	—	c.12	34
	(phragm.)	38	76	34	41	68	12	c.31
Loc. USGS 22599	(phragm.)	74	70	34	40	65	12	c.41
CAS 13111	(body ch.)	101	41	29	47	—	14	38
	(phragm.)	70	61	31.5	38.5	64	13	c.38
Loc. CAS 29011	(body ch.)	115	—	—	43.5	—	c.17	40-50 obsol.
	(phragm.)	69	65	c.32	41	63	13	c.45
	"	51	68	33	40	62	13	46
	"	40	73	35	39	—	13	39
McM J918	(apert.)	120	c.38	27.5	50	—	12	c.40
	(phragm.)	80/68	c.73	37	40	—	13	40
McM J920	(phragm.)	c.75	c.64	c.32	c.40	—	c.13	c.39
	"	26	73	33	40.5	—	14	32
	"	20	73	32.5	40	—	12	26
	"	16	75	33	37.5	—	11.5	—
McM J921	(phragm.)	52	62	33	38.5	63	14	40
	"	25	72	32	40	—	14	29
McM J923	(body ch.)	58	—	—	—	—	—	—
	(phragm.)	48	66	33	37.5	63	13	34
McM J925	(phragm.)	41	75	36.5	39	—	c.12	c.28
McM J926	(apert.)	80	46	30	c.46	—	c.13	33
	(phragm.)	c.40	—	—	—	—	—	c.32
McM J924	(phragm.)	c.48/41	76	38	34	57	14	35
McM J922	(body ch.)	62	—	—	—	—	—	—
	(phragm.)	53	c.68	34	c.42	67	c.15	32

Docidoceras (Pseudocidoceras ?) cf. *D. camachoi*, n. sp. Pl. 42, fig. 2

Material. — One complete body chamber, internal mold with part of the phragmocone from CAS 29011 (CAS 13120). Associated with *D. camachoi*, *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

The specimen differs from *D. camachoi* in the more weakly prosoradiate costae which are retained at almost full strength on the body chamber. This could be a 'stunted' variant of *D. camachoi* which reached adulthood before the ribbing became modified, similar as described from *D. cf. widebayense*.

<i>Measurements.</i> —		Dmm	W%	H%	U%	P	S
CAS 13120	(apert.)	85	40	26	48	18	40
	(phragm.)	50	64	34	c.42	—	—

Docidoceras (Pseudocidoceras), n. sp. indet. A Pl. 36, figs. 4a, b, 5

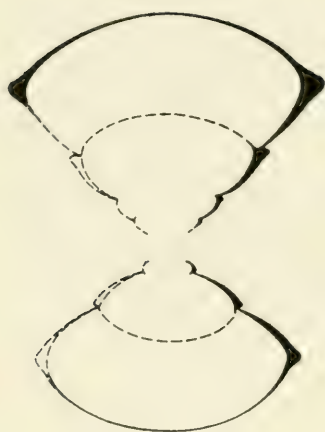
Material. — One incomplete deformed internal mold with pathological body chamber from USGS 19862 (USNM 160252); one almost complete internal mold from USGS 12405 (USNM 160251). Associated with *D. widebayense* and *D. camachoi*, *S. sowerbyi* Zone, Kialagvik Formation, Wide Bay.

This form is distinguished from *D. widebayense*, n. sp. and *D. camachoi*, n.sp., by the smaller diameter, the denser costation, especially regarding the primaries (about 20 primaries on the two last halfwhorls of the phragmocone), and the wider umbilicus (U 40%).

Docidoceras (?) [? *Pseudocidoceras* or n. subgen.], n. sp. indet. B Pl. 43, figs. 1a, b; Text-fig. 50

Material. — One incomplete phragmocone with crushed body chamber, largely with shell, from WA 3 at the base of the *amplexatens* zonule (McM J930).

Description. — This specimen is typically 'coronate,' *Teloceras*-like, at least throughout the last two whorls of the phragmocone which are broad and strongly depressed 'lenticular' with rounded lateral edge; the inner flank ('umbilical slope') and the broad externside are gently and evenly rounded. The widely spaced primaries consist of blunt plications barely reaching the umbilical seam. There are strong mid-lateral spines on the last three



Text-fig. 50. — Cross-section of *Docidoceras* [*?Pseudocidoceras* or n. subgen.], n. sp. indet. B, incomplete phragmocone, loc. WA 3 at the base of the *E. amplectens* zonule (McM J 930); $\times 1$.

whorls of the phragmocone (9 to 10 per halfwhorl) which, on the inner whorls, are molded into the subsequent umbilical seam. The secondaries are moderately strong, rather dense (40 per halfwhorl) and weakly prosoradiate.

The body chamber remains strongly depressed with dominant quasi-midlateral nodes or spines; the inner flanks are smooth, the secondaries become blunt, stronger prosoradiate and, on the internal mold, partly obsolete. The aperture is simple with moderately oblique peristome, slight constriction and weak collar.

Affinities. — This specimen may be a strongly 'coronate' *D.* (*Pseudocidoceras*); however, it is distinguished by the spines, the blunt primaries and the almost rectiradiate secondaries. The body chamber shows close affinities to South American *Pseudotoites*, and the whole shell resembles *P.* (?) (n. subgen.) *sphaeroceroides* (Tornquist) (see Westermann, 1964b, pl. 9, fig. 7); however, the whorls are not ovate and the secondaries stronger and almost straight. This species is probably closely related with the associated *D.* ? (*Pseudocidoceras?*) *paucinodosum*, n. sp. which is distinguished by somewhat smaller, less depressed and less ornate whorls.

Measurements. —		Dmm	W%	H%	U%	P	S
McM J930	(apert.)	c.100	—	—	—	9-10	(c.35 obsol.)
	(phragm.)	54	67	35	41	9	40

Docidoceras? (Pseudocidoceras?) paucinodosum Westermann, n. sp.

Pl. 43, figs. 2a, b; Pl. 44, figs. 1, 2; Text-fig. 51

Holotype. — Pl. 43, fig. 2a, b, Text-fig. 51; complete internal mold except for nucleus, slightly deformed. Repository: CAS 13123.

Locus typicus. — Southeastern side of Wide Bay, Calif. Acad. Sci. locality 29014 (field no. 108/C.E.L. No. 68).

Stratum typicum. — "Dark grey sandstone with basaltic dike", *E. amplexens* zonule, upper Kialagvik Formation.

Derivatio nominis. — With respect to the widely spaced nodes or spines.

Diagnosis. — A species of *Docidoceras* ? [or *Pseudotoites*?] with evolute depressed whorls bearing distant reduced blunt primaries, with strong lateral nodes or spines, and dense, straight to weakly prosoradiate blunt secondaries.

Material. — The holotype; one partly distorted internal mold and two fragments from scree of WA 5 (McM J934); two almost complete internal molds, somewhat distorted, from subgreywacke of USGS 19828. *E. amplexens* zonule of the early *S. sowerbyi* Zone; ? one fragment from the *O. sauzei* Zone of WA 12 (McM J 1044) [? reworked]. All from the Kialagvik Formation at Wide Bay.

Description. — The innermost whorls are not preserved. From approximately 20 mm diameter, the whorls are depressed subelliptical or lenticular to slightly ovate in section, often with more or less rounded lateral edge. The umbilicus is wide (35-40%), moderately deep and subconical. The phragmocone whorls embrace about one-half, the umbilical seam barely touching the lateral nodes. The body chamber occupies approximately one full whorl, egressing especially with the last one-half whorl so that the aperture embraces only about one-quarter of the phragmocone. As usual, width growth decreases or ceases with the body chamber.

The aperture is simple and moderately oblique, with slight constriction and weak collar or lateral flange. The full diameter is 75-85 mm, a modest size for a macroconchiate *Pseudotoites* or *Docidoceras*.

The costation of the inner whorls (internal mold) consists of widely spaced (7-9 per halfwhorl) blunt primaries, fading away near the umbilical seam, but ending laterally in strong nodes or



Text-fig. 51. — Cross-section of *Docidoceras* ? (*Pseudocidoceras* ?) *paucinodolum*, n. sp., holotype, with complete body chamber; $\times 1$.



spines. There are five to six times as many densely set, straight or somewhat prosoradiate secondaries which arise from and between the lateral nodes and run evenly over the broad externside.

On the long body chamber, the primaries of the internal mold become blunt plications and retract from the inner flank (umbilical slope), or they may become obsolete. The lateral nodes remain strong and usually rounded, more rarely bullae-like; but may weaken at the end. The secondaries usually remain dense becoming blunt to almost obsolete; however, they may again increase markedly in strength and spacing near the end of the body chamber. A weak umbolateral groove may be developed.

The septum is bullate with the outer saddle axis being slightly stronger than the inner one. The suture is unknown.

Comparison. — The intermediate and outer whorls resemble *Docidoceras*, especially *D. (Pseudocidoceras)*, in the dimensions and the strength of the lateral nodes/spines. However, the development of blunt primaries, dense secondaries, and prominent nodes especially on the body chamber are strongly reminiscent of South American *Pseudotoites*, such as *P. transatlanticus* (Tornquist) which it

also resembles in thickness and coiling or *P.* (?) (n. subgen.) *sphaerocerooides* (Tornquist) which has similar "coronate" inner whorls. This species is, therefore, intermediate between *Docidoceras* and *Pseudotoites*, and possibly closest affiliated with *P.* (?) *sphaerocerooides* which should probably be distinguished as a new subgenus.

Measurements. —		Dmm	W%	H%	U%	P	S
Holotype	(apert.)	80	41	26	45	7	36
	(body ch.)	57	53	39	36	7	44
	(phragm.)	c.43	c.67	37	37	8	—
McM J934	(apert.)	c.85	c.36.5	c.27	c.43.5	8-9	45
	(body ch.)	c.60	c.44	c.30	c.42	8	c.50
	(phragm.)	35-40	—	—	—	8-9	50-60
USNM 160261	(apert.)	75	37	27	c.44	9	45
	(begin. body ch.)	c.43	c.60	c.37	c.37	c.8	—

Subgenus **Docidoceras (Trilobiticeras)** Buckman, 1919

Docidoceras (Trilobiticeras ?), n. sp. indet. (♂)

Pl. 44, figs. 4a-c

Material. — One complete internal mold with test remains, penultimate halfwhorl deformed, from Shell L 546. Upper Kialagvik Formation, *S. sowerbyi* Zone, associated with *D.* (*Pseudocidoceras*) *camachoi*, n.sp. Collections of Shell Oil Co., Seattle, Washington.

Description. — The small phragmocone of 18 mm diameter is a typical 'coronate.' The whorls are strongly depressed, double as wide as broad with sharp lateral edge at about two-fifths whorl height, and widely umbilicate (38%). There are 22 prosoradiate somewhat blunt primaries on the last full whorl which carry lateral tubercules and bifurcate into strong prosoradiate secondaries. Medio-ventrally, the secondaries are markedly arched and tend to flatten and to be slightly off-set. The penultimate whorl (c. 6 mm D), as visible in the conical umbilicus, is similar in shape and ornamentation. The primaries commence at about 5 mm diameter by extension from the bullae-like lateral nodes.

The body chamber is approximately 27 mm in diameter, three-fourths whorls in length, and becomes more evolute and more rounded (W/H c.1.9→1.45). The lateral nodes remain strong while the primaries become obsolete. The secondaries increase rapidly in

strength and spacing and pass evenly convex over the externside.

The aperture expands laterally into a weak flange with thickened test which, on the internal mold, is separated from the body chamber by a constriction. The collar or flange extends into lateral lappets of which the left one is preserved with 5 mm length. Their accurate original shape is uncertain but consistent with the simple 'spatulate' type of *Trilobiticer* (Buckman, 1919, pl. 140).

The septal suture is incompletely preserved; nevertheless, the two subequal E L and L/U₂ saddles of *Docidoceras* and other Ototidae with bullate septum can be recognized.

Affinities. — The phragmocone of this typical microconch cannot be distinguished from inner whorls of the much larger *D.* (*Pseudocidoceras*) which abounds in the same bed (compare with Pl. 41, fig. 3; Text-figs. 47-49).

This specimen is distinguished from all described species of *D.* (*Trilobiticer*) by the strongly prosoradiate costae with ventrally convex secondaries, and probably by the weaker apertural collar. These are the same features which distinguish the probably corresponding macroconchs *D.* (*Pseudocidoceras*) and *D.* (*Docidoceras*).

Suggested sexual dimorphism. — Considering morphology and association, this small specimen is probably the male of *D.* (*Pseudocidoceras*). Astounding is the scarcity of this microconch, *i.e.* a single specimen in a sample of approximately 500 *Docidoceras* *s.s.* A number of possible reasons for such numerical miss-matches have been suggested (Westermann, 1964b, p. 36), a combination of which could have caused this strong disproportion. More material is needed to establish clearly the suggested dimorphic relationship and to place this form in a species previously known only from its macroconch (female).

<i>Measurements.</i> —		Dmm	W%	H%	U%	P	S
Shell L546	(apert.)	c.27	c.47	c.31.5	c.41	13	c.25
	(phragm.)	18	c.67	c.37	c.34.5	12	26
	"	16	c.72	37.5	38	—	—

Genus **PSEUDOTOITES** Spath, 1939

Type species by original designation. — *Stephanoceras leicharti* Neumayr, 1885, from the early Bajocian (*s.s.*) Newmarracarra Limestone of Western Australia.

Only the Australian representatives have previously been re-described and revised (Arkell, 1954; Westermann, 1964b) while the South American species are still poorly known. The Alaskan forms are described for the first time. My search in 1965 for new material of *Pseudotoites* in the Andes of Neuquén and Mendoza, Argentina, was successful only with respect to *P. singularis* (Gottsche) and *P. (Latotoites) evolutum* (Tornquist) which occur abundantly just below the *Emileia* - *Otoites* - *Papilliceras* assemblage of the *O. sauzei* Zone. No significant new material is available of the somewhat dubious species *P. (?)* (n. subgen.?) *sphaerocerooides* (Tornquist), *P. transatlanticus* (Tornquist), and *P. argentinus* Arkell, all based on single or a few poorly preserved specimens and inadequately described. Furthermore, the holotypes of *P. sphaerocerooides* and *P. argentinus* had apparently not been returned after being lent to the late Dr. W. J. Arkell and were not available for re-examination.

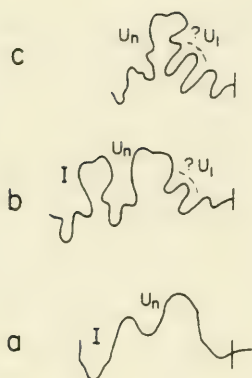
Subgenus **PSEUDOTOITES (PSEUDOTOITES)** Spath, 1939

The following tentative diagnosis is here given for *Pseudotoites* (*Pseudotoites*): Large Otoitidae (macroconchs); nucleus with sub-circular, rounded ovate or slightly depressed elliptical whorls and reduced primaries which are retracted from the umbilical seam; intermediate whorls inflated-cadicone with depressed strongly ovate section, lateral tubercles or bullae absent or weak; outer one to two whorls becoming more evolute and compressed, ornament with strong lateral nodes and bullae, primaries and often secondaries becoming obsolete. Costae prosoradiate throughout. Peristome simple and strongly oblique.

Pseudotoites (Pseudotoites) cf. P. argentinus Arkell, 1954 Pls. 45, 46,
Text-figs. 53-56

Cf. 1954. *Pseudotoites argentinus* n. sp., Arkell (Australia), Phil. Trans. Roy. Soc. London, B., vol. 237, p. 592, pl. 40, figs. 1a-c.

Material. — One almost complete specimen with damaged body chamber from USGS 19922 (USNM 160262); one partly crushed

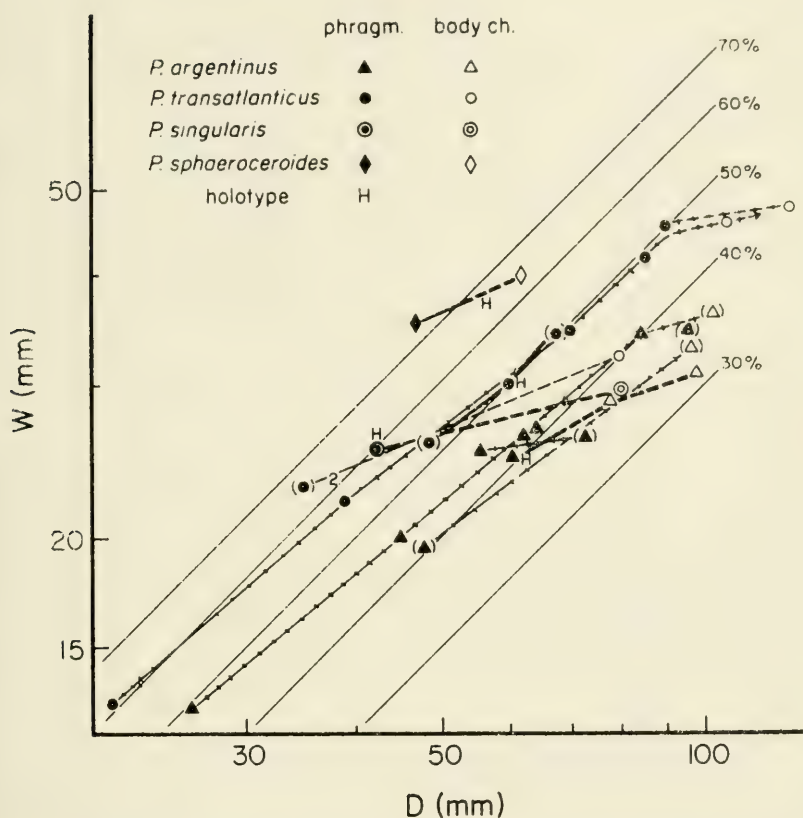


Text-fig. 52 a-c.—Internal septal suture of *Pseudotoites* sp. indet. from the *P. singularis* assemblage (*S. sowerbyi* or basal *O. sauzei* Zone) of Los Molles (bed 6) in Neuquén, Argentina; magnified. a. at 1.2 mm W, b. at 4 mm W and 2.5 mm H, c. at 4.5 mm W and 3 mm H. Note the secondary U_n lobe and the apparently divided U_1 lobe.

phragmocone from USGS 12405 (USNM 160263); one fragmentary specimen with parts of phragmocone and body chamber from USGS 19862; two phragmocones with parts of body chambers from WA 13w at c.18 m (McM J935, 936); one phragmocone with beginning of body chamber from WA 10 at 11 m (McM J 938). All moderately to well-preserved internal molds with test remains from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, Kialagvik Formation at Wide Bay.

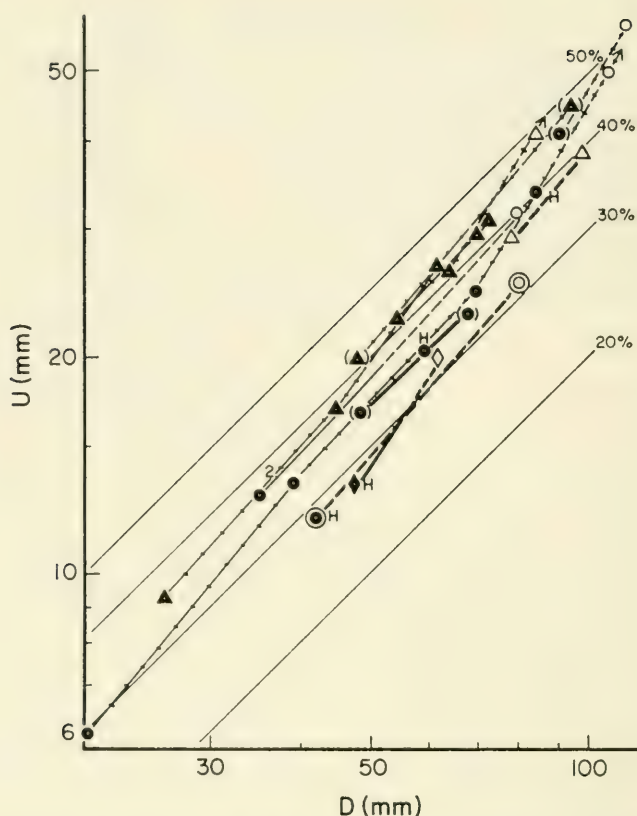
Description.—The whorls are evolute (40-45% U), almost 'serpenticone' throughout, with rounded subcircular to slightly depressed ovate section, becoming strongly ovate and often compressed on the last whorl and body chamber. The umbilical slope (or inner flank) is only slightly rounded and slopes moderately steep to the umbilical seam situated well outside the lateral nodes of the preceding whorl. The maximum whorl width lies at about one-third whorl height or even lower on the last whorl and close to the umbilical seam on the body chamber. The externside is more or less evenly and highly arched.

The costation consists of reduced short prosoradiate primaries, strong lateral nodes or short bullae, and prosoradiate densely spaced blunt secondaries. There are 9-11 blunt primaries per halfwhorl on the inner whorls, only slightly increasing in number on the outer whorls; they arise gradually near the middle of the umbilical slope and retract from the seam finally becoming obsolete or merely minor



Text-fig. 53. — Scatter with growth lines for relative whorl width ('thickness' = $W:D$) of *Pseudotoites* spp. from South America (No. 2: "*Emilia* aff. *singularis* Jaw." = *P. cf. transatlanticus*) and Wide Bay (serrated lines). Note that the growth rate decreases throughout the phragmocone and body chamber and that separation of species is poor.

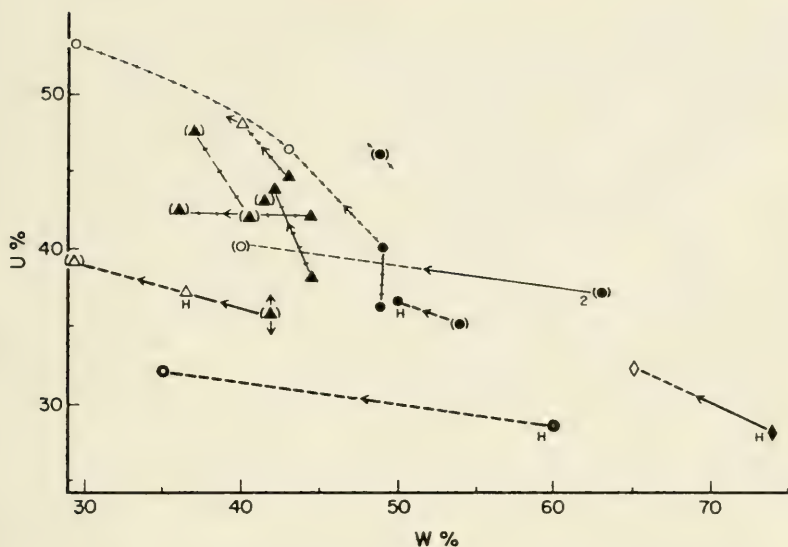
extensions of the bullae or nodes. There are about four to five times as many fine and blunt secondaries (35-50 per halfwhorl on inner whorls, 45-55 per halfwhorl on outer whorls) which are born from the nodes or bullae by intercalation and cross the externside more or less strongly convex, sometimes with median flattening; they become extremely dense and finally obsolete on the last whorl, including the body chamber. Some blunt, faint and more distant ribs may be developed toward the end of the body chamber.



Text-fig. 54.—Scatter with growth lines for relative umbilical width (U:D) of *Pseudotoites* spp. (Same symbols as Text-fig. 53). Note that the growth rate increases throughout the phragmocone and body chamber, and that separation of species is poor.

The septum is typically bullate. The suture is highly complex with narrow finger-like endings of all lobes; E, L, U_2 and U_3 reach a common radius, the E/L saddle is slightly larger than the L/ U_2 saddle, at least on one specimen; the U_2/U_3 saddle is rather broad but only one-half as high as the L/ U_2 saddle; U_3 is strongly oblique.

Discussion.—In naming this species for '*Emileia* aff. *singularis* Gottsche' of Jaworski (1926, p. 255, pl. 2, figs. 3a-c), *non* Gottsche, Arkell (1954, p. 592) nevertheless figured a new speci-



Text-fig. 55.—Scatter with growth lines for relative umbilical width vs. relative whorl width (U%:W%) of *Pseudotoites* spp. from South America and Wide Bay (symbols as in Text-fig. 53). The combined parameters for 'coiling' and 'thickness' illustrate the specific dimensional differences which may or may not be significant.

men from Espinazito Pass as the holotype. *P. argentinus* is said to be "much more evolute and larger than Gottsche's original", but neither description nor measurements were given. However, Jaworski's measurement and figures show that the phragmocone of his specimen has much broader whorls than the holotype and that Jaworski's specimen is indeed closely affiliated with *P. transatlanticus* (Tornquist) (Text-figs. 53,54). The inner whorls of the holotype are unknown because the umbilicus was not developed.

The affinities of the Wide Bay form with *P. argentinus*, probably known only in the holotype, can only be conjectured. The former is almost certainly more evolute (end phragmocone U c. 42-47% vs. c. 35%, aperture U 45-50% vs. 39%). Among the Australian species, *P. leicharti* is most closely affiliated but distinguished by less evolute whorls with denser primaries and wider spaced secondaries.

Measurements. —		Dmm	W%	H%	U%	P	S
USNM 160263	(phragm.)	(75)70	c.41.5	c.30	43	9	45
		45	—	—	—	10	c.40
USNM 160262	(body ch.)	c.102	c.35	—	—	10	—
	"	85	40	29.5	48	9.5	47
	(phragm.)	64	43	31	44.5	10	—
McM J 935	(body ch.)	(c.150)	—	—	—	—	(coarse, blunt)
	"	c.110	—	—	—	c.11	(60-70)
	(phragm.)	62	42	29	43.5	c.13	c.55
	"	45	44.5	33.5	38	11-12	c.50
	"	26	49	34.5	35	10-11	—
McM J 936	(phragm.)	95	c.37	27.5	c.47.5	13-14	c.50
	(phragm.)	c.48	c.40.5	c.32	c.42	11	c.35
McM J 938	(phragm., end?)	73	c.36	29	42.5	12.5	55
	"	55	45.5	34.5	42	11	c.42

Appendix to measurements. —

Holotype of <i>P. argentinus</i> (from original figs.)		Dmm	W%	H%	U%	P	S
	(apert.)	98	c.27	c.32	39	8	(obsol.)
	(body ch.)	78	36.5	38.5	c.37	8	50-55
	(phragm. ?)	c.60	c.42	c.30	—	c.8	—

Pseudotoites (Pseudotoites) cf. *P. transatlanticus* (Tornquist) 1898

Pl. 47, Text-figs. 53-55, 57

(?)1898., *Stephanoceras transatlanticum* sp. nov., Tornquist, (Espinazito) Palaontol. Abhandl. Jena., vol. 8, Heft 2, pl. 5, fig. 4.

? 1926, *Emileia* aff. *singularis* Gottsche, Jaworski (Mendoza), Actas Acad. Nac. Cienc. Rep. Argentina, vol. 9, p. 255, pl. 2, figs. 3a-c.

Material. — One large internal mold with complete body chamber, only right side preserved, from USGS 19862 (USNM 160264); one crushed phragmocone with incomplete body chamber from USGS 21251. Both from the *Pseudocidoceras* zonule of the *S. sowerbyi* Zone, upper Kialagvik Formation of Wide Bay.

Description. — The innermost whorls are thick, moderately evolute and depressed elliptical in section; the intermediate whorls become more widely umbilicate and depressed ovate in section; the last whorl of the phragmocone and the body chamber become increasingly strongly evolute and ovate with the maximal width at about one-third to one-fourth whorl height. The body chamber is one and one-fourth whorls long and egresses strongly up to the aperture which barely embraces the venter of the preceding whorl. During the last onehalf whorl, (absolute) whorl height remains

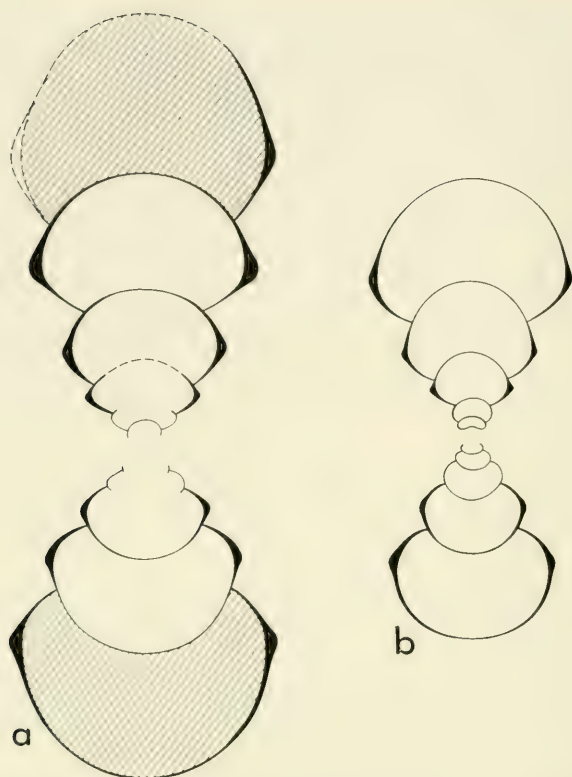
approximately constant while width appears to contract slightly and gradually. The simple peristome is somewhat oblique and the internal mold has a strong lateral flange following a constriction, probably corresponding to shell thickening.

The primaries and especially the secondaries are prosoradiate throughout. The nucleus (20 mm D) has strong primaries which are retracted from the umbilical seam, carry small lateral tubercles, and trifurcate into moderately strong, continuous and typically 'convex' secondaries. On the intermediate and last whorls, the primaries become increasingly shorter and more blunt, leaving a smooth band besides the umbilical seam, and swell distally until they produce strong bullae; the secondaries become blunt, much denser, weaker, and finally obsolete on the body chamber leaving only broad plications.

Septum and suture are as in *P. cf. argentinus* described above; the suture is complex with suspensive umbilical elements.

Of special interest is the presence on both specimens of a strong umbolateral groove (here named) adjacent to the umbilical seam, reaching halfway up the inner flank (or umbilical slope) and extending from the end of the phragmocone to the middle of the body chamber where it becomes gradually obscure. A faint trace of this groove is also visible on the inner whorls of the phragmocone. The umbolateral groove contains remnants of a dark porous material, the surface of which is in continuation with the internal mold of the whorl. Common in the described *Docidoceras* (*Pseudocidoceras*) from Wide Bay, it is probably related to the attachment of the paired retractor muscle which has been known in this position from slight impressions and organic remnants in many ammonites since G. C. Crick (1898) and has most recently been discussed by F. W. Jordan (1968).

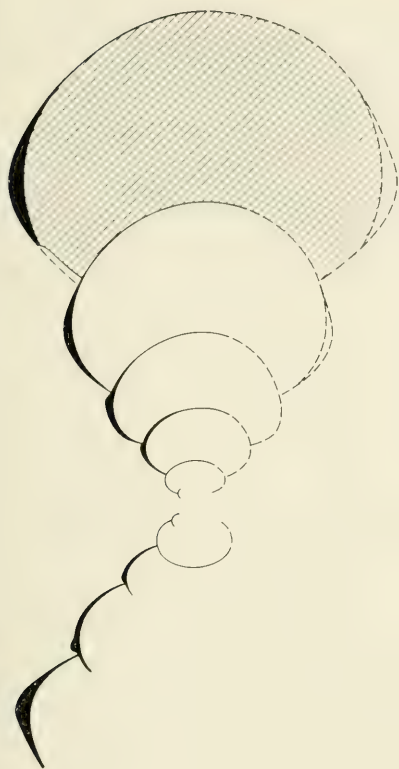
Discussion.—The two specimens differ from *P. cf. argentinus* apparently only in the broader, more depressed, and slightly more involute whorls. They closely resemble the poorly preserved holotype (the only known specimen) of the somewhat dubious *P. transatlanticus* (Tornquist). The holotype (refigured: Arkell, 1954, p. 592, fig. 13), preserved with slightly more than one exposed whorl, is entirely more or less strongly crushed and its dimensional features can therefore only be conjectured (see table below). It is



Text-figs. 56 a-b.— Cross-section of *Pseudotoites* cf. *P. argentinus* Arkell, *S. swerbyi* Zone of Wide Bay; X1. a. Almost complete specimen with damaged body chamber, loc. USGS 19922 (USNM 160262). b. Phragmocone, loc. WA 13 in the *Pseudocidoceras* zonule (McM J 935).

apparent that the probably last whorl of the phragmocone is moderately thick, evolute and depressed ovate in section.

The evolute specimen described by Jaworski (1926, pl. 2, fig. 3) as '*Emileia* aff. *singularis* Gottsche' and placed by Arkell in *P. argentinus*, is also close to *P. transatlanticus*, which, in turn, is intermediate in coiling and whorl sections between *P. singularis* and *P. argentinus*.



Text-fig. 57. — Cross-section of *Pseudotoites* cf. *P. transatlanticus* (Tornquist), complete on one side only, loc. USGS 19862 in the *Pseudocidoceras* zonule (USGS 160264); note the umbolateral groove on the body chamber; $\times 1$.

Measurements. —

		Dmm	W%	H%	U%	P	S
USNM 160264	(apert.)	160	c.22	c.29	54	12	obsol.
	(body ch.)	108	43	32	46.5	10	c.50 (obsol.)
	(phragm.)	85	49.5	—	40	9.5	40-50
	"	70	49	37	36	10	—
		39	56.5	36	34.5	11	—
		20	65	45	30	9	30

Appendix to measurements. —

	Dmm	W%	H%	U%	P	S
Holotype of <i>P. transatlanticus</i> (from plastotype):						
(end phragm. body ch.)	68	c.50	37.5	c.34	10	c.50
(phragm.)	60	c.50	c.33.5	36.5	10	c.50
"	c.48	c.54	c.37	c.35	10	45-50
' <i>Emileia</i> aff. <i>singularis</i> Jaworski', non Gottsche (from text and figs.)						
(body ch.)	c.80	c.40	c.30	c.40	c.40	c.41
(phragm.)	c.35	c.65	c.33	c.37	9	c.42

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Фауна аммонитов формации Киалагвик у залива Широкого (Уауд бэй), полуостров Аляска. Часть 2ая. Зона *Sonnina sowerbyi*

Герд Е. Г. Вестерманн.

Конспект.

Граница между формациями Киалагвик и Шеликова в настоящее время проведена у основания Калловиянского согласия (параконформности); это согласуется с основным определением и исключает сильный гетероханизм.

Зона *S. sowerbyi* (стандартная) состоит из нижней части по крайней мере толщиной более 35 метров, состоящей из подгрейваки, грейваки и алевролитов, содержащих набор *Eudmetoceras ampletens* [*amplectens zonule*] и из верхней части, 50 - 100 метров, состоящей из глинистых сланцев с конкрециями содержащими набор *Pseudocidoceras* [*Pseudocidoceras zonule*]. Часть непрочных сланцев часто нехватает из-за сбросов раздела над *amplectens zonule*. Нижележащая зона *E. howelli* отделена от верхней зоны 80 - 100 метрами обнаженных, немых и малоисследованных кластичных пород; перекрывающаяся зона *O. sauzoi* отделена песчаниками и глинистым сланцем общей мощностью в 110 - 130 метров.

Ampletens zonule дала *Eudmetoceras* (*Euaetetoceras*) *amplectens* (Buckman), *Docidoceras* (?), *Bradfordia*? (*Praeoppelia*) и *Hebotoxites* и поэтому её приурочивают в нижнюю *S. sowerbyi* зону, *L. discites* подзону, к самым низам байоса. Зонула *Pseudocidoceras* включает, внизу, *Sonninia* (*Euhoploceras*), *Eudmetoceras klimakomphalum* (Vacek) и *Docidoceras s. s.*, подтверждая также *L. discites* подзону и выше - обильный эволют *Witchellia* указывающий на среднюю или верхнюю зону *S. sowerbyi*.

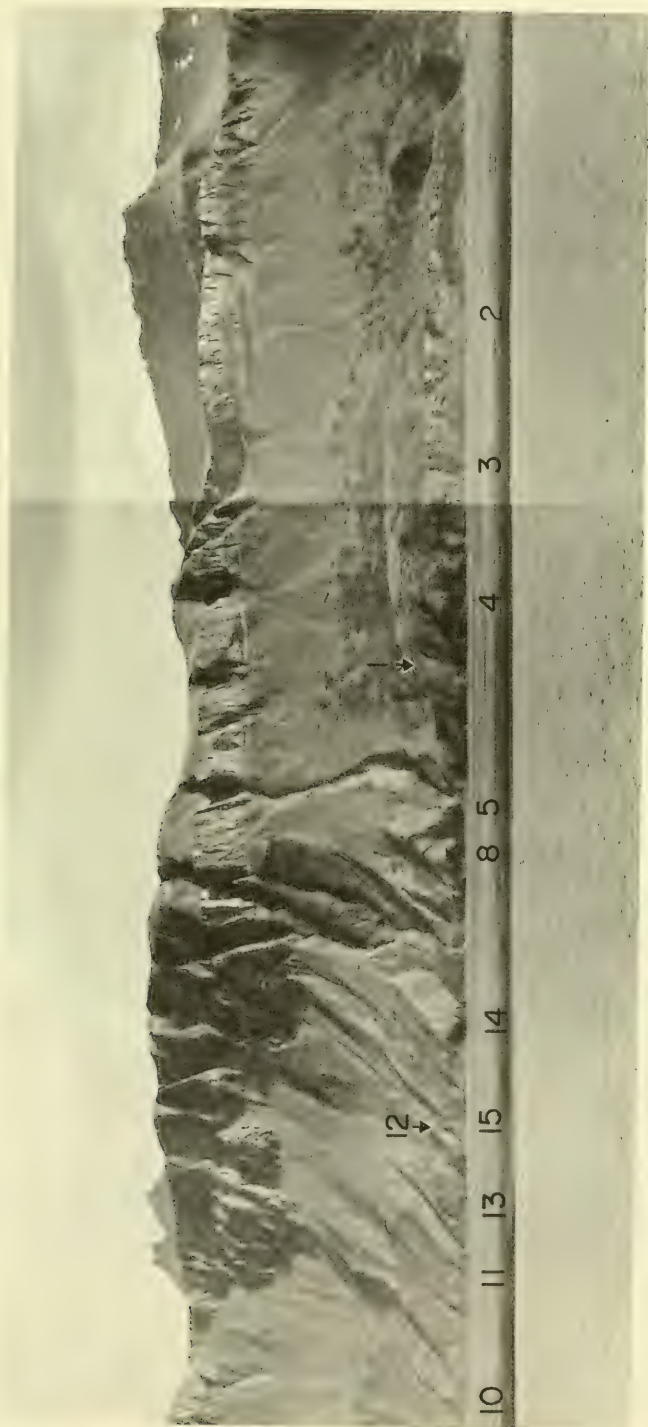
Аммоноидеа разделены на: 15 родов, ни одного нового; 13 под родов - из которых 3 новых [*Sonninia* (*Alaskoceras*), *Docidoceras* (*Pseudocidoceras*), *Bradfordia*? (*Praeoppelia*); 30 видов - из которых от 13 до 20 новых и 9 из которых называются [*Partschiceras ellipticum*, *Pseudolioceras costistriatum*, *Sonninia* (*Euhoploceras*) *bifurcata*, *S.* (*Alaskoceras*) *alaskensis*, *Witchellia sutneroides*, *Docidoceras* (*Pseudocidoceras*) *widebayense*, *D. (P.) samachoi*, *Bradfordia*?, (*Praeoppelia*) *oppeliiformis*]; и 2 подвида - [*Pseudolioceras mcintocki fastigatum*, *Eudmetoceras* (*Euaetetoceras*) *klimakomphalum discoidale*].

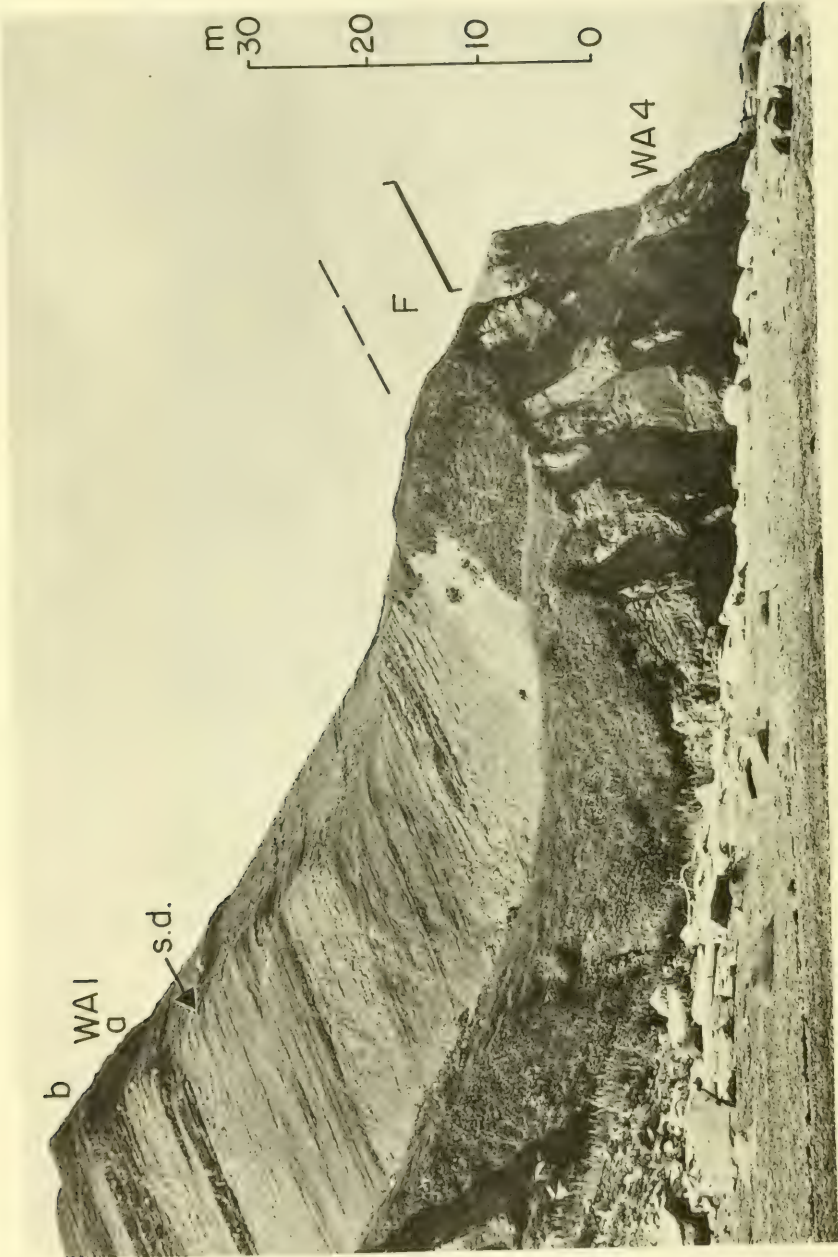
Около половины родов и под родов Аммонитина распространены шире чем в Европе. Сродство их более близкое с Европой и потом с Южной Америкой. Сродство с Западной Тихоокеанской областью (Западной Австралией и Индонезией) слабое и можно считать, что оно произошло косвенно, через Европу и Южную Америку. Все роды с других материков известны и только *pseudotoites* приурочены исключительно к Тихому Океану. Высокое фаунистическое разнообразие указывает на более низкую пироту и/или более низкие температуры, чем в настоящее время, что также показано распределением видов.

PLATES

EXPLANATION OF PLATE 1

Southeast side of Wide Bay, middle part, tele-photograph from the mouth of Short Creek on the other side of the bay. The Kialagvik Formation forms the coastal cliffs and lower slopes, the Shelikof formation the upper slopes and cliffs. The numbers indicate my fossil localities (WA-prescript omitted, cf. Text-figs. 2-3).





EXPLANATION OF PLATE 2

Bajocian section of the upper Kialagvik Formation at southeast shore of Wide Bay, 1.7 km east of Preston Creek (locs. WA 1 and 4), viewed from the east. The bluff is formed by the massive subgreywackes of the *E. amplexens* zonule (lower *S. sowerbyi* Zone); overlain by several meters of deteriorated shale marking a bedding-plane fault zone (F) which has suppressed the shales with concretions of the *Pseudocidoceras* zonule; the middle of the section consists of unfossiliferous interbedded silty shales, sandstones and mudstones bearing a sedimentary dyke (s.d.) in a small steeply dipping fault; at the top are thick-bedded greywacke, subgreywacke siltstones, and mudstones of the *Parabigotites* zonule (*O. sauzei* Zone).

EXPLANATION OF PLATE 3

Coastal bluff of the *E. amplexens* zonule (lower *S. sowerbyi* Zone). Above: 1.2 km east of Preston Creek (Loc. WA 2); massive fossiliferous subgreywacke underlain by poorly fossiliferous interbedded silty shale, mudstone and greywacke (cf. Pl. 4). Below: 1.8 km east of Preston Creek (Loc. WA 8); massive fossiliferous subgreywacke truncated by steep fault with basaltic dyke; in the middleground are Bajocian interbedded shales, sandstones, and mudstones with at least most of *Pseudocidoceras* zonule missing (probably bedding-plane fault above *E. amplexens* zonule); in the background are shales, siltstones, and sandstones of the Callovian Shelikof Formation.





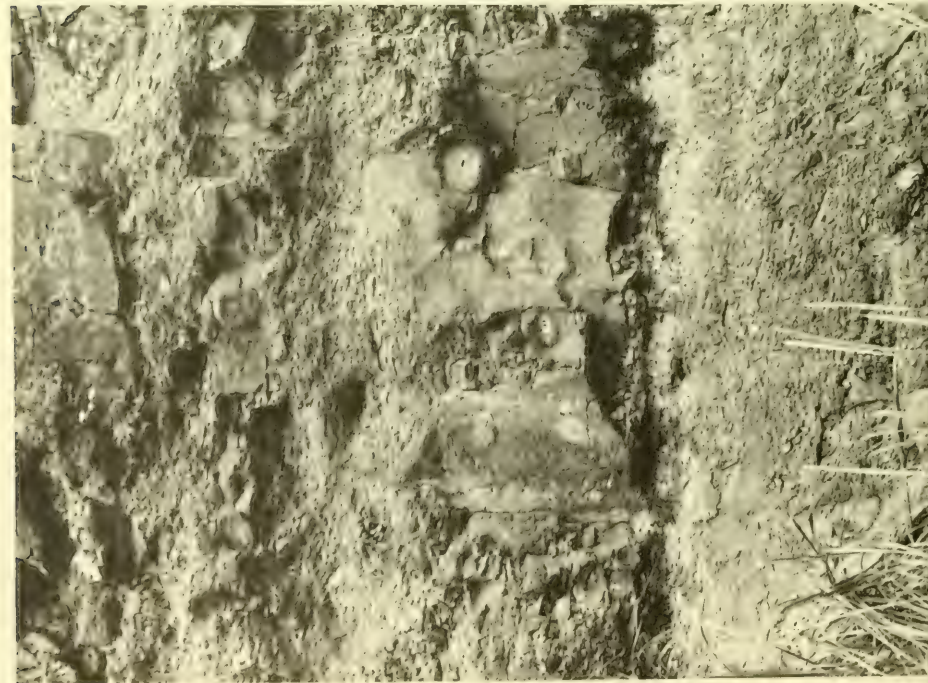
EXPLANATION OF PLATE 4

Coastal bluff of the *E. amplexans* zonule (lower *S. sowerbyi* Zone), Kialagvik Formation; 1.2 km east of Preston Creek (loc. WA 2 marked by arrow; cf. Pl. 3). Left: Interbedded silty shales, mudstones, and greywackes, below, and massive subgreywacke with fissility due to bedding-plane faulting (cf. Pl. 2), above. Right: Detail of greywacke beds of locality WA 2, graded with sole structures.

EXPLANATION OF PLATE 5

Coastal cliff of the *Pseudocidocras* zonule (*S. sowerbyi* Zone), Kialagvik Formation; 2.5 km east of Preston Creek (loc. WA 10; marker bed at 10.5 m indicated); highly fossiliferous beds with calcareous concretions. The overlying unfossiliferous interbedded silty shales, sandstones, and mudstones, and the greywacke and subgreywacke beds of the *O. sauzei* Zone are largely covered by vegetation. Above follow the shaley, arenaceous, and partly carbonaceous and tuffaceous beds of the Callovian Shelikof Formation.





EXPLANATION OF PLATE 6

Detail of the coastal bluff of the lower *E. howelli* Zone, middle Kialagvik Formation; northwest shore of Wide Bay, near Pass Creek (locs. WB 9-11). Somewhat weathered muddy subgreywacke, above, and mudstone, below, with calcareous concretions containing abundant wood remains and ammonites, particularly *Erycitoides howelli* (White) and *E. (Kialagvikites) kialagvikensis* (White).

EXPLANATION OF PLATE 7

Coastal bluff of the upper *E. howelli* Zone, middle *Kialagvik* Formation; unfossiliferous; west end of northwest shore of Wide Bay. Bedded sandstones overlaid by conglomerate and angular-bedded mudstone, followed by massive subgreywacke.





EXPLANATION OF PLATE 8

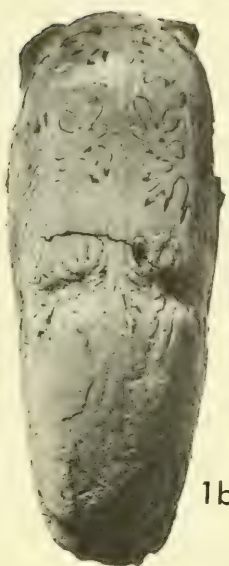
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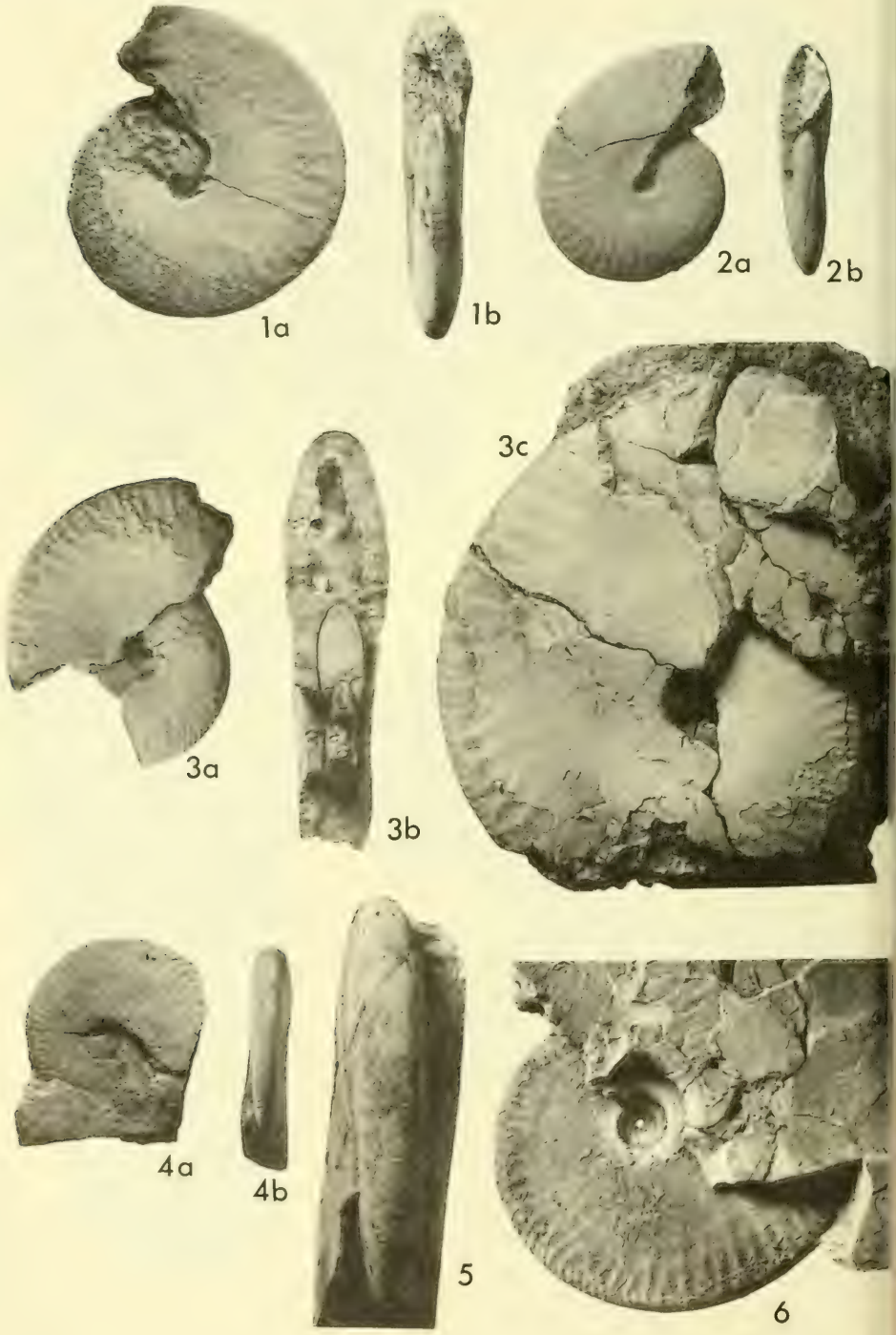
Figure	Page
1, 2. Partschiceras ellipticum Westermann, n. sp.	38
Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 1a-c. Damaged internal mold, totally septate, from 8 m below top of <i>E. amplexans</i> zonule. Loc. WA 8. McM J 962. 2. Damaged internal mold with septal suture, totally septate, from the <i>Pseudocidoceras</i> zonule. Loc. WA 10 at 2.5m. McM J 1013.	
3a-c. Holcophylloceras costisparsum Imlay	40
Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Damaged internal mold with septal suture, totally septate. Loc. USGS 19862. USNM 160921.	
4. Phylloceras (Zetoceras) cf. P. zetes (d'Orb.)	36
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule. Fragment of phragmocone with septal suture and test remains. Loc. WA 10 at 15m. McM J 1018.	

EXPLANATION OF PLATE 9

Natural size if not otherwise indicated.

Figure		Page
1a-b.	Holcophylloceras costisparsum Imlay	40
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Damaged phragmocone with incomplete one-half whorl body chamber, internal mold with test remains. Loc. USGS 21251, USNM 160920.	
2, 3a-b.	Lytoceras sp. aff. L. eudesianum (Orb.)	42
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule, Wide Bay. Totally septate, incomplete internal mold. Loc. WA 10, basal 2 m. McM J 1010, 3a-b. Large phragmocone, probably with beginning of body chamber, internal mold with test remains. Loc. WA 10 at 14-16m. McM J 1005.	





EXPLANATION OF PLATE 10

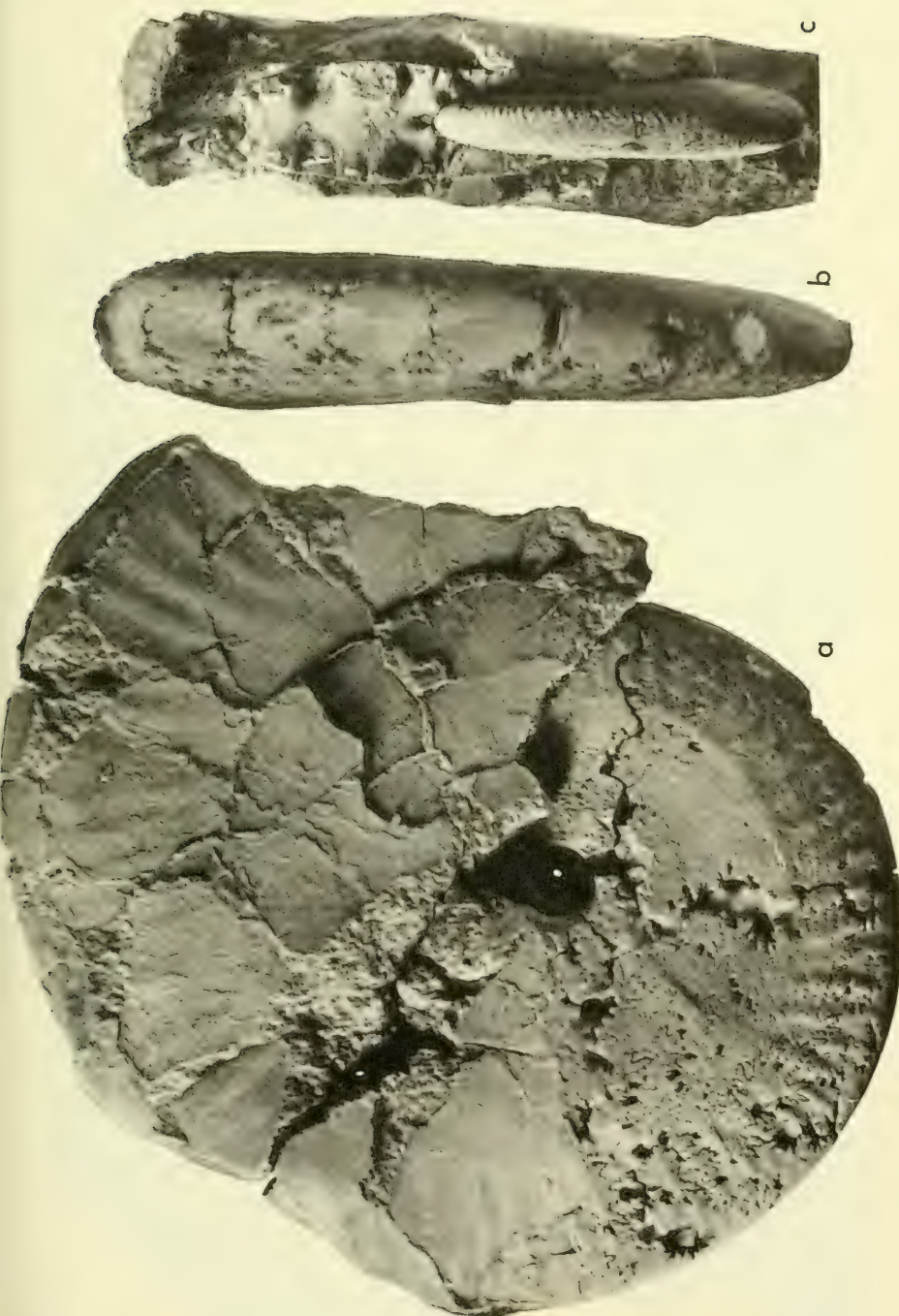
Natural size if not otherwise indicated.

Figure		Page
1-2b.	Hebetoxyites sp. aff. H. hebes Buckman Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexans</i> zonule, Wide Bay. 1a-b. Complete specimen with left lappet. Loc. WA 5. McM J 1043. 2a-b. Almost complete specimen. Loc. WA 8 upper part. McM J 1041.	44
3-6.	Bradfordia? (Praeoppelia) oppeliiformis Westermann, n. sp. Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 3a-c. Phrag- mocone with incomplete crushed body chamber; 3a. inner whorls; 3b. section of phragmocone. Loc. USGS 21252. USNM 160923. 4a-b. Inner whorls of specimen with incomplete body chamber from the <i>E. amplexans</i> zonule. Scree of Loc. WA 5. McM J 1040. 5. Venter of penultimate phragmocone whorl; same specimen as Pl. 12, fig. 1. 6. Holotype penultimate phragmocone whorl; see Pl. 11, figs. a-c.	48

EXPLANATION OF PLATE 11

Natural size if not otherwise indicated.

Figure		Page
a-c.	Bradfordia? (Praeoppelia) oppeliiformis Westermann, n. sp. Kialagvik Formation, (lower ?) <i>S. sowerbyi</i> Zone, Wide Bay. Holotype, phragmocone with one-half whorl, incomplete and damaged body chamber. b-c. Ventral views of ultimate and penultimate half-whorls with section. Loc. USGS 19863, USNM 160922 (see Pl. 10, fig. 6).	48





EXPLANATION OF PLATE 12

Natural size if not otherwise indicated.

Figure

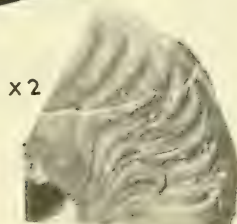
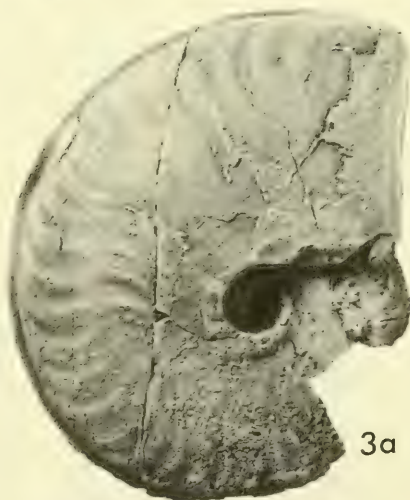
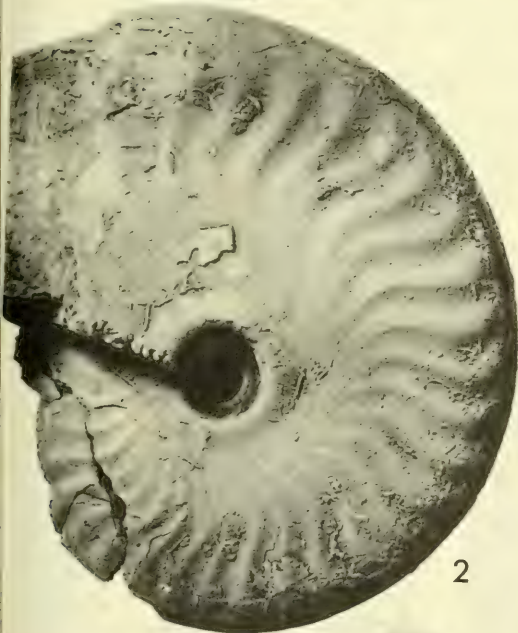
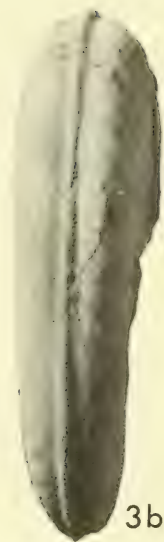
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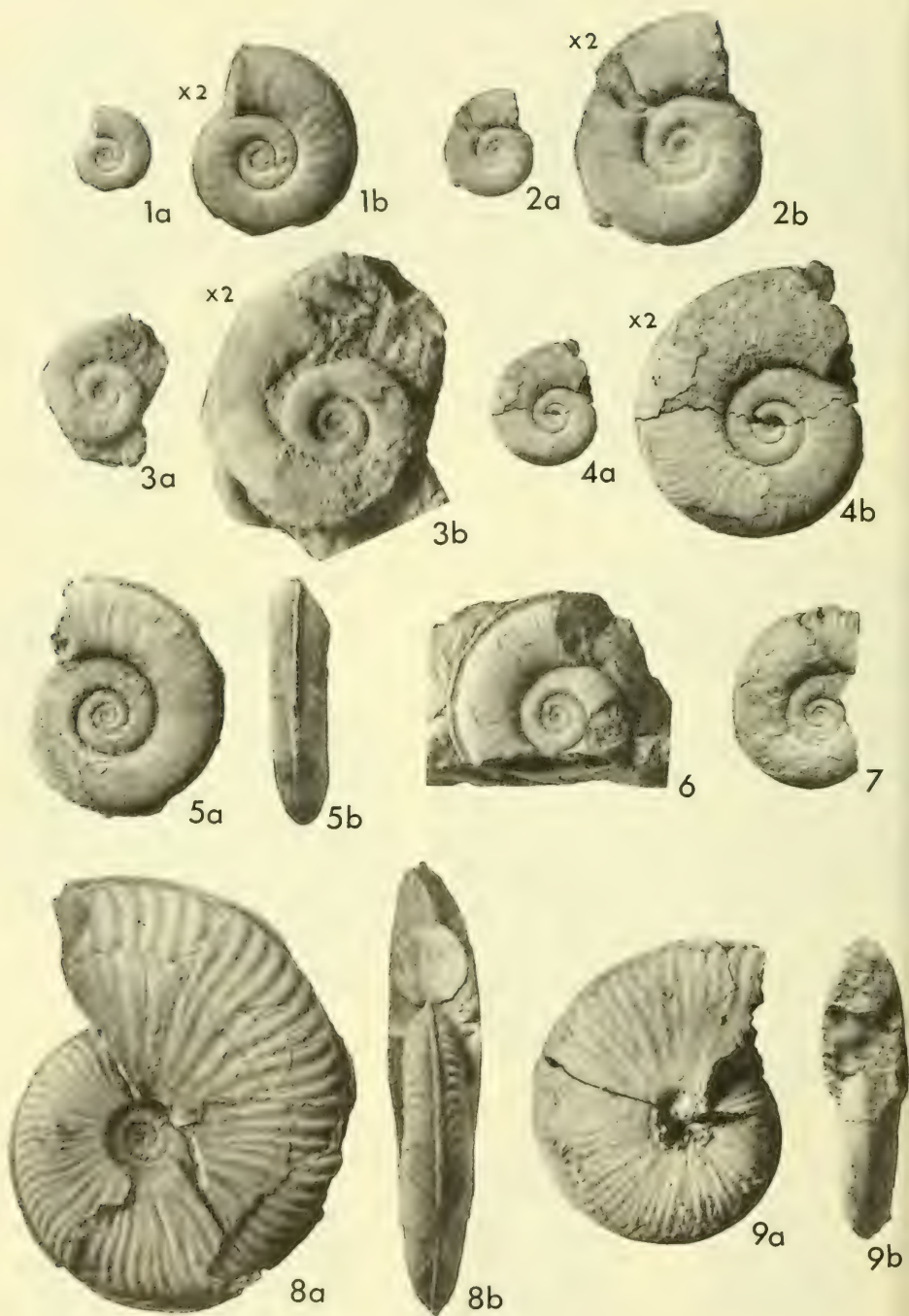
- 1, 2. **Bradfordia?** (**Praeoppelia**) **oppeliiformis** Westermann, n. sp. 48
Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1. Complete
phragmocone. Loc. CAS 29011. CAS 13109. (see Pl. 10, fig.
5). 2. Probably complete phragmocone. Loc. UW WA-111 lot
37. UW 13180.

EXPLANATION OF PLATE 13

Natural size if not otherwise indicated.

Figure		Page
1, 2.	<i>Pseudolioceras macklintocki fastigatum</i> Westermann, n. subsp.	52
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 1a-b. Holotype, phragmocone with incomplete body chamber. Loc. USGS 21252. USNM 160294. 2. Phragmocone, internal mold. Loc. CAS 29011. CAS 13110.	
3-6.	<i>Pseudolioceras costistriatum</i> Westermann, n. sp.	56
	3a-b. Holotype, almost complete internal mold with one-half whorl body chamber, from the upper <i>Pseudocidoceras</i> zonule. Loc. WA 11 at 30m. McM J 1056. 4a-b. Small (?juv.) specimen, partly with test; 4b detail of 4a, X2. Loc. USGS 19862, USNM 160295. 5. Small (?juv.) specimen with some test, from the <i>Pseudocidoceras</i> zonule. Loc. WA 11 at 30m. McM J 1056a. 6. Fragment of large phragmocone. Same loc. as 5. McM J 1056b.	





EXPLANATION OF PLATE 14

Natural size if not otherwise indicated.

Figure

Page

- 1-7. **Asthenoceras** sp. aff. **A. nannodes** (Buckman) ♂ and ♀ 61
 From a single calcareous concretion of the Kialagvik Formation, *Pseudocidoceras* zonule, *S. sowerbyi* Zone, Loc. WA 10 at 11m.
 1a-b. Almost complete microconch; 1b X2. McM J 1037c.
 2a-b. Complete microconch with lappet; 2b X2. McM J 1037b.
 3a-b. Complete microconch with exfoliated body chamber and base of lappets; 3b X2, McM J 1037a. 4a-b. Incomplete specimen with some test and preserved septal suture, probably septate up to end, macroconch ?; 4b X2. McM J 1036a. 5 a-b. Almost complete macroconch with one-half whorl body chamber, internal mold. McM J 1035b. 6. Macroconch with about one-quarter whorl body chamber and test remains. McM J 1035. 7. Macroconch with one-quarter whorl body chamber, internal mold. McM J 1035a.
- 8, 9. **Eudmetoceras** (**Euaptetoceras**) **klimakomphalum discoidale** Westermann, n. subsp. 75
 Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 8. Paratype, small (?juv.) phragmocone with crushed body chamber, test remains and keel. Loc. USGS 12405, USNM 160928. 9. Phragmocone, internal mold. Loc. USGS 12405, USNM 160929.

EXPLANATION OF PLATE 15

Natural size if not otherwise indicated.

Figure		Page
a-b.	Eudmetoceras (Eudmetoceras) aff. E. eudmetum Buckman	72
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Fully septate internal mold. Loc. USGS 21252, USNM 160926.	





EXPLANATION OF PLATE 16

Natural size if not otherwise indicated.

Figure

Page

- 1, 2. **Eudmetoceras (Euaptetoceras) klimakomphalum discoidale** Westermann, n. subsp. 75
 Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1a-f. Holotype, fully septate internal mold; 1c-d, nucleus of same specimen, X1 and X2; 1e, ultimate half-whorl removed; 1f, septal suture on ultimate half-whorl, X2. Loc. USGS 12405. USNM 160927. 2. Fragment, probably of the same subspecies, with test showing strongly projected growth lines. Loc. USGS 21251, USNM 160928.

EXPLANATION OF PLATE 17

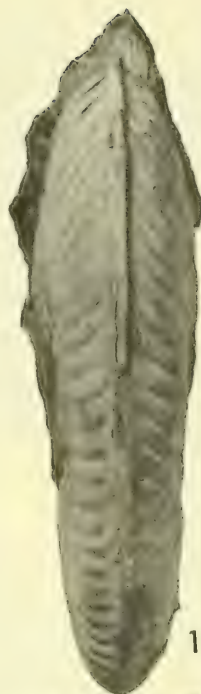
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Figure		Page
1a-c.	Eudmetoceras (Euaptetoceras) klimakomphalum discoidale Westermann, n. subsp.	75
	Kialagvik formation, <i>S. sowerbyi</i> Zone, Wide Bay. Incomplete large phragmocone; 1b, penultimate whorl, partly with preserved hollow-floored keel. Loc. USGS 19863. USNM 160230.	
2a-b.	Eudmetoceras (Euaptetoceras) sp. aff. E. nucleospinosum Westermann	81
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Large phragmocone, partly crushed; 2b, inner whorls of same specimen. Loc. USGS 12405. USNM 160231.	





1a



1b



2a



2b

EXPLANATION OF PLATE 18

Natural size if not otherwise indicated.

Figure		Page
1a-b.	Cf. Eudmetoceras (Euaptetoceras) klimakomphalum discoidale Westermann, n. subsp.	75
	Kialagvik formation, <i>S. sowerbyi</i> Zone, Wide Bay. Incomplete phragmocone with approximately one-quarter whorl body chamber and test showing faint concentric markings and strongly projected growth lines. Loc. 21251, USNM 160232.	
2a-b.	Eudmetoceras (Euaptetoceras) klimakomphalum discoidale Westermann, n. subsp.	75
	Kialagvik formation, <i>S. sowerbyi</i> Zone, Wide Bay. Incomplete large phragmocone. Loc. USGS 19863, USNM 160233.	

EXPLANATION OF PLATE 19

Natural size if not otherwise indicated.

Figure		Page
	Eudmetoceras (Euaptetoceras) amplexens (Buckman)	83
	[var. or ?subsp. ' <i>aguilonia</i> ' Imlay]	
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexens</i> zonule,	
	Wide Bay. Largest specimen, with aperture (D 200mm);	
	X 0.75. Loc. WA 8. McM J 968.	





a



b



c

EXPLANATION OF PLATE 20

Natural size if not otherwise indicated.

Figure		Page
a-c.	Eudmetoceras (Euaptetoceras) amplexens (Buckman) [var. or ?subsp. ' <i>aguilonia</i> ' Imlay] Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexens</i> zonule, Wide Bay. a, damaged specimen with aperture, Loc. WA 8 upper part; b-c, part of body chamber removed.	83

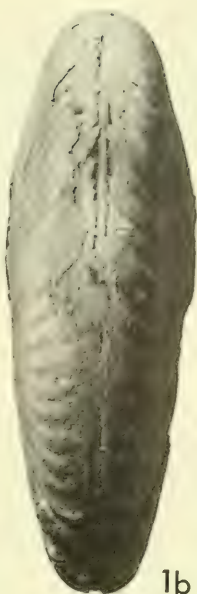
EXPLANATION OF PLATE 21

Natural size if not otherwise indicated.

Figure	Page
1, 2. Eudmetoceras (Euaptetoceras) amplexens (Buckman)	83
Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 1a-d. Fully septate internal mold with test remains; 1d, part of outer whorls removed. Loc. USGS 12405. USNM 160234. 2. Fragment with aperture, from <i>E. amplexens</i> beds. Loc. WA 8. McM J 952.	
3. Cf. Eudmetoceras s.l. indet. [$? \delta$]	90
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexens</i> zonule, Wide Bay. Plasticine cast of natural mold. Loc. WA 8 lower part. McM J 958.	



1a



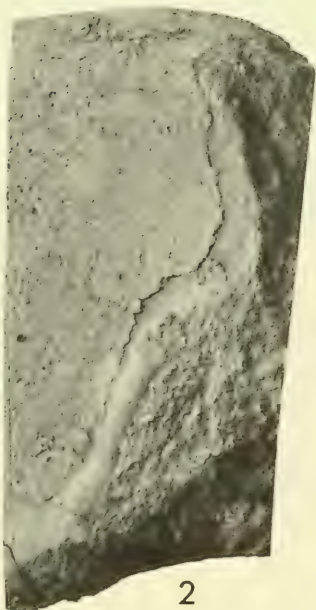
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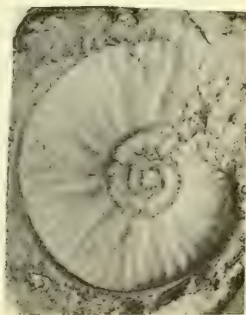
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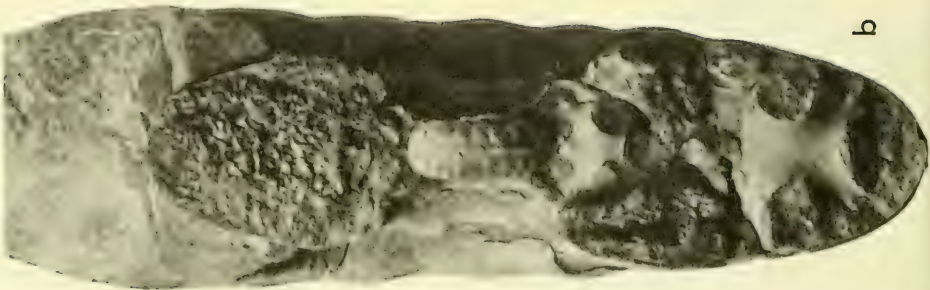
1d



2



3



EXPLANATION OF PLATE 22

Natural size if not otherwise indicated.

Figure

Page

- a-b. **Planammatoceras (Pseudammatoceras ?) sp. aff. P. benneri**
 (Hoffman) 90
 Kialagvik Formation, *S. soxerbyi* Zone, *Pseudocidoceras* zonule,
 Wide Bay. Large specimen with aperture (D 195mm); a,
 $\times 0.7$; b, last half-whorl of body chamber and part of phrag-
 mocone removed, $\times 1$. Loc. USGS 21251. USNM 160235.

EXPLANATION OF PLATE 23

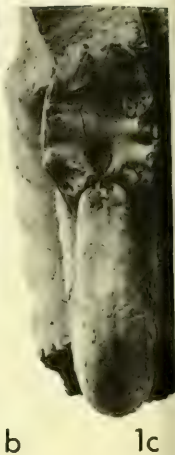
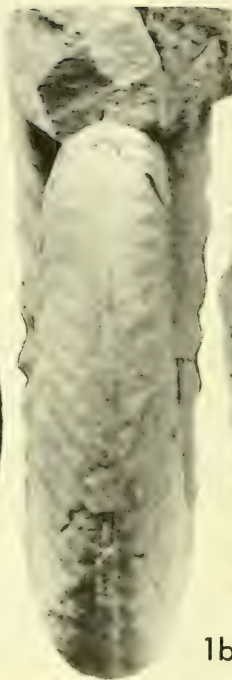
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Figure

Page

- 1-2. **Sonninia (Euhoploceras) bifurcata** Westermann, n. sp. 94
 Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1a-b. Holotype, phragmocone with one-quarter whorl of somewhat crushed body chamber, internal mold. Loc. USGS 12405. USNM 160236. 2. Body chamber fragment, slightly crushed, Loc. USGS 19869. USNM 160237. 3a-b. Inner whorls of spinose variant; 3b, ultimate one-quarter whorl removed. Loc. USGS 12405. USNM 160238.





EXPLANATION OF PLATE 24

Natural size if not otherwise indicated.

Figure

Page

- 1-2. **Sonninia (Euhoploceras) bifurcata** Westermann, n. sp. 94
Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1a-c. Phragmocone with beginning of body chamber, compressed and weakly ornate variant. Loc. USGS 12405. USNM 160240. 2. Incomplete phragmocone with one-half whorl of body chamber, spinose variant. Loc. USGS 19869. USNM 160240.

EXPLANATION OF PLATE 25

Natural size if not otherwise indicated.

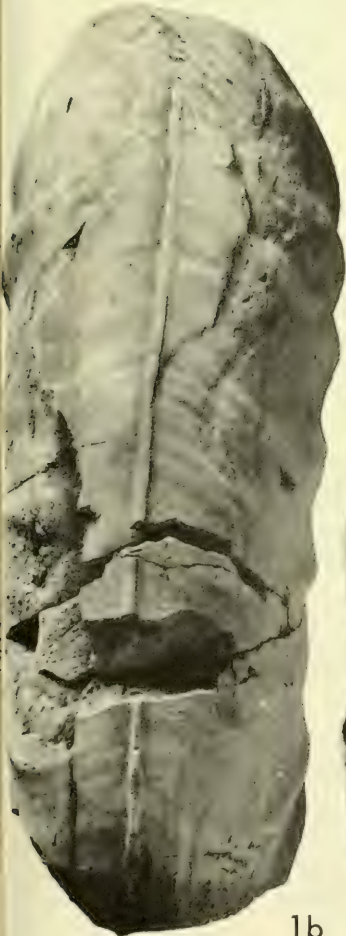
Figure

Page

- 1-2. **Sonninia (Euhoploceras) bifurcata** Westermann, n. sp. 94
 Kialagvik Formation, *S. sowerbyi* Zone, *Pseudocidoceras* zonule,
 Wide Bay. 1a-b. Large body chamber fragment with weak
 secondaries, internal mold. Loc. WA 15 at 10m. McM J 1049.
 2. Incomplete phragmocone with somewhat crushed body
 chamber fragment. Loc. USGS 19869. USNM 160242.



1a



1b



2



EXPLANATION OF PLATE 26

Natural size if not otherwise indicated.

Figure

Page

- 1-2. **Sonninia (Euhoploceras) bifurcata** Westermann, n. sp. 94
Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1. Phragmocone with one-half whorl of body chamber, terminally deformed; average form, from the *Pseudocidoceras* zonule. Loc. WA 10. McM J 975. 2. Phragmocone with one-half whorl of somewhat crushed body chamber; average form. Loc. USGS 12405. USNM 160241.

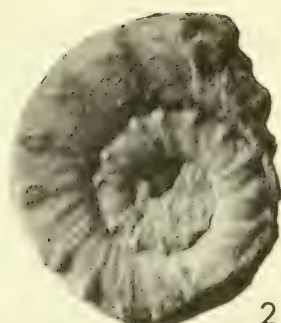
EXPLANATION OF PLATE 27

Natural size if not otherwise indicated.

Figure	Page
1. Sonninia (Euhoploceras ?) sp. indet	102
Incomplete phragmocone, from <i>E. amplexens</i> zonule, <i>S. sowerbyi</i> Zone, Kialagvik Formation. Loc. WA 8, Wide Bay, McM J 959a.	
2-7b. Sonninia (Alaskoceras) alaskensis Westermann, n. sp.	103
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule (+subjacent shales), Wide Bay. 2. Internal mold of phragmocone. Loc. WA 13w, McM J 1023a. 3a-c. Holotype, phragmocone with some test and hollow-floored spines developed from the surrounding matrix, from scree of the <i>Pseudocidoceras</i> zonule; 3c, ultimate half-whorl removed. Loc. WA 10. McM J 1021. 4. Inner whorls of phragmocone, internal mold, Loc. WA 15 at 22m. McM J 1024. 5. Almost complete internal mold with test and sockets of hollow-floored spines. Scree of Loc. WA 10. McM J 1020. 6a-b. Nucleus of phragmocone, partly with test; 6b X 2. Loc. WA 10. McM J 1021a. 7a-b. Parts of large phragmocone with hollow-floored spines developed from surrounding matrix, ventral views. Loc. WA 15 at 3m. McM J 1027.	



1



2



3a



3b



3c

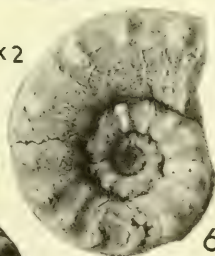


4

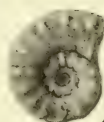


5

x2



6b



6a



7a



7b



1a



1b



1c



2a



2b

EXPLANATION OF PLATE 28

Natural size if not otherwise indicated.

Figure		Page
1-2b.	Witchellia sutneroides Westermann, n. sp.	116
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 1a-c. Holotype, phragmocone with test remains. Loc. USGS 21251. USNM 160243. 2a-b. Almost complete internal mold with one-half whorl of body chamber, compressed, involute and weakly ornate variant; 2b, penultimate whorl. Loc. USGS 12405. USNM 160255.	

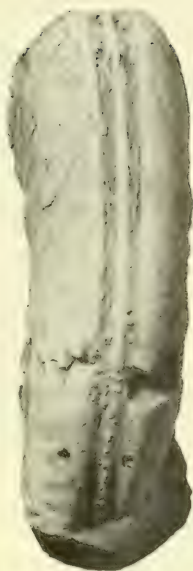
EXPLANATION OF PLATE 29

Natural size if not otherwise indicated.

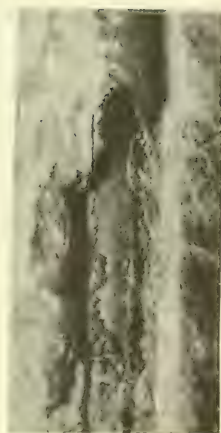
Figure		Page
1-2.	Witchellia sutneroides Westermann, n. sp.	116
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, (upper) <i>Pseudocidoceras</i> zonule, Wide Bay. 1a-b. Incomplete phragmocone. Loc. WA 10 at 14-16m. McM J 949. 2. Hollow-floored keel, partly broken, on beginning of body chamber, with conellae-like substance on keel floor, X 3. Loc. WA 10 at 13-14m. McM J 943.	
3a-b.	Witchellia cf. W. sutneroides Westermann, n. sp.	116
	Incomplete internal mold with one-half whorl of body chamber. <i>S. sowerbyi</i> Zone, Kialagvik formation, Wide Bay. Loc. USGS 19868. USNM 160247.	



1a



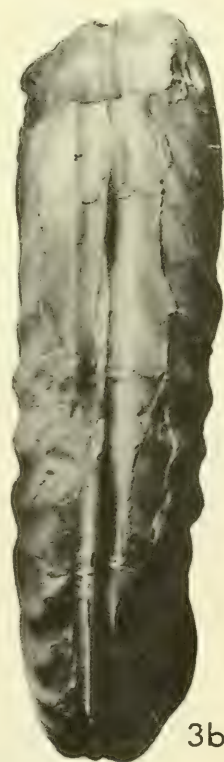
1b



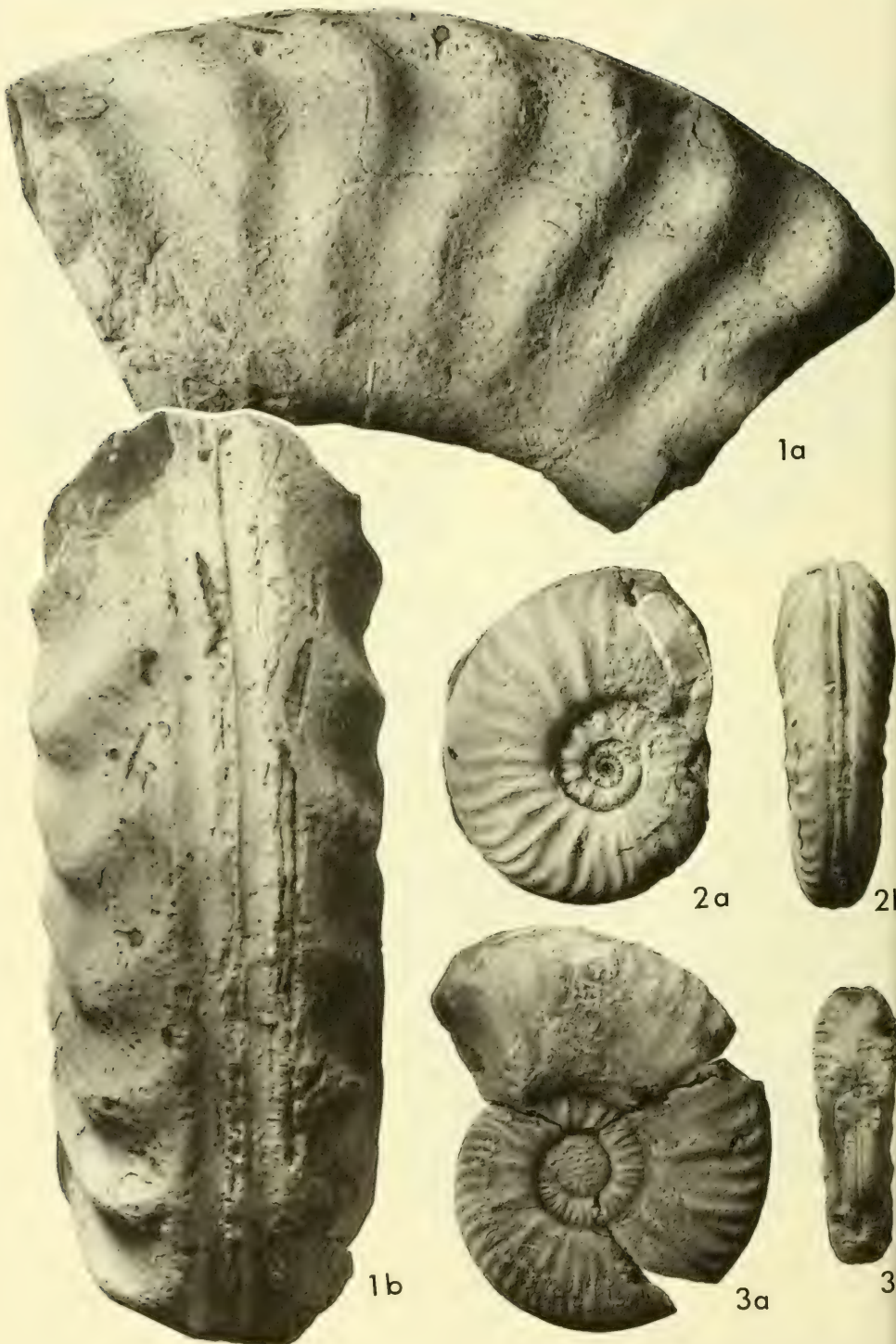
2



3a



3b



EXPLANATION OF PLATE 30

Natural size if not otherwise indicated.

Figure

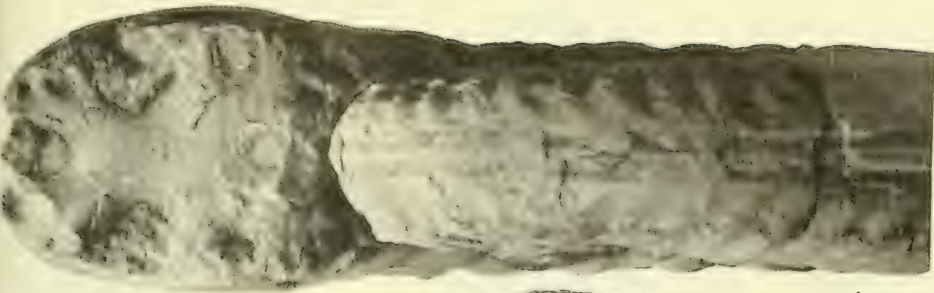
Page

- 1-3b. **Witchellia sutneroides** Westermann, n. sp. 116
 Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1a-b.
 Large body chamber fragment. Scree of Loc. WA 13. McM
 J 950. 2a-b. Immature (or microchonchate ?) specimen with
 one-half whorl of body chamber. Loc. USGS 19922. USNM
 160246. 3a-b. Immature (?) specimen with one-quarter
 whorl of body chamber. Loc. 12405. USNM 160347.

EXPLANATION OF PLATE 31

Natural size if not otherwise indicated.

Figure	Page
a-c. Witchellia sutneroides Westermann, n. sp.	116
Kialagvik Formation,, <i>S. sowerbyi</i> Zone, Wide Bay. Largest phragmocone, with apparent shell duplication (see Text-fig. 38), X 0.9; b-c, the single photograph has been cut because of space limitation. Loc. USGS 21251. USNM 160248.	



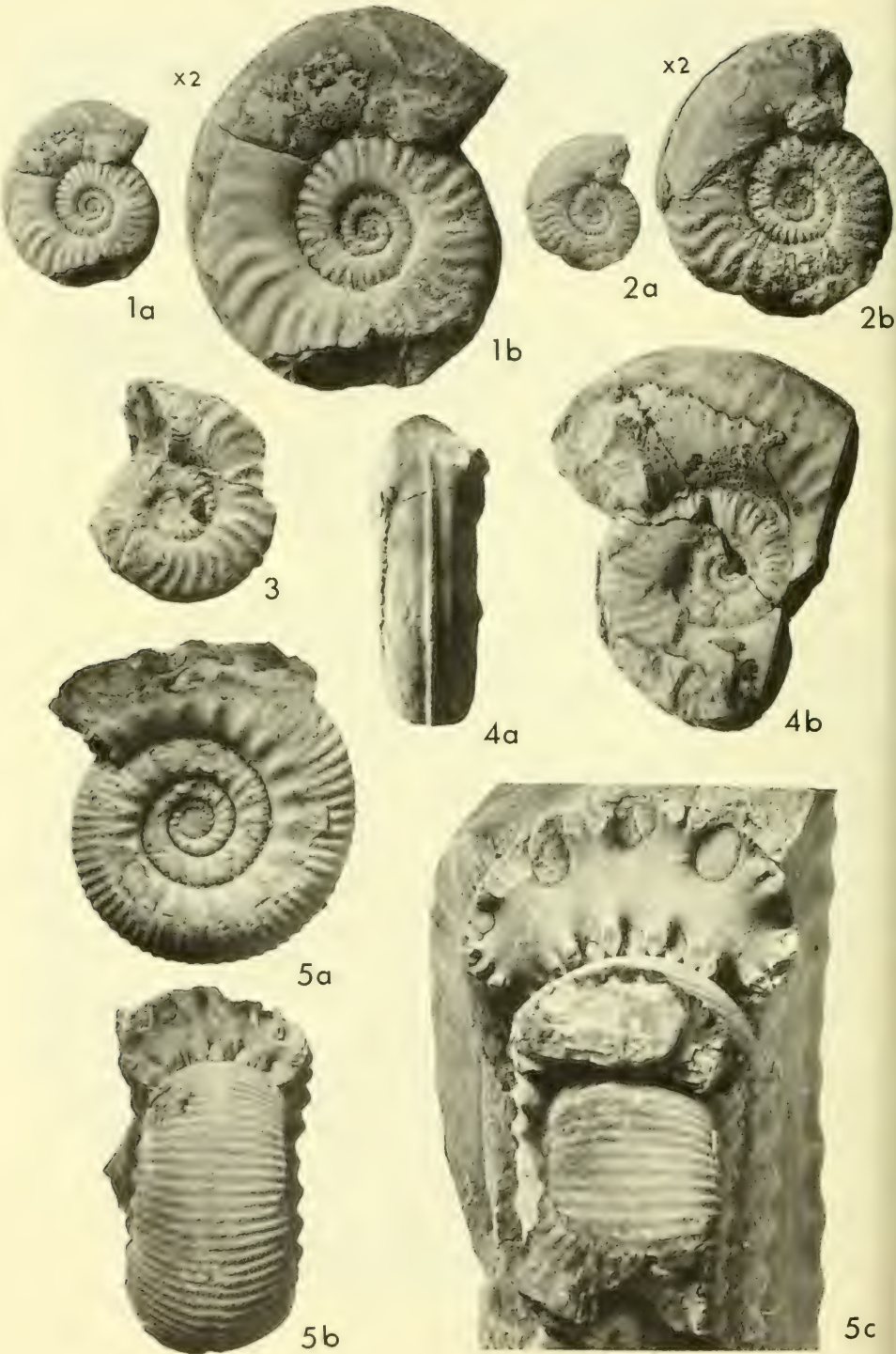
b



c



a



EXPLANATION OF PLATE 32

Natural size if not otherwise indicated.

Figure	Page
1-2b. Pelekodites cf. P. pelekus Buckman	126
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule, Wide Bay. 1a-b. Complete specimen with test and lappet; 1b X2 Loc. WA 10 at 11m. McM J 1028b. 2a-b. Same preservation and loc. as fig. 1; 2b X 2. McM J 1028a.	
3-4b. Pelekodites (Spatulites ?) n. sp. aff. P. spatians (Buckman) ..	127
Kialagvik Formation, <i>S. sowerbyi</i> Zone, upper <i>Pseudocidoceras</i> zonule, Wide Bay. 3. Incomplete specimen with apparently adult body chamber. Loc. WA 11 at 32m. McM J 1294. 4a-b. Somewhat crushed phragmocone with part of body chamber including aperture with lappet. WA 11 at 22m. McM J 939.	
5a-c. Docidoceras (Docidoceras ?) sp. aff. D. longalvum (Vacek)	134
Phragmocone with incomplete body chamber; 5a-b, inner whorls of fig. 5c (same specimen Pl. 33, figs. a-b).	

EXPLANATION OF PLATE 33

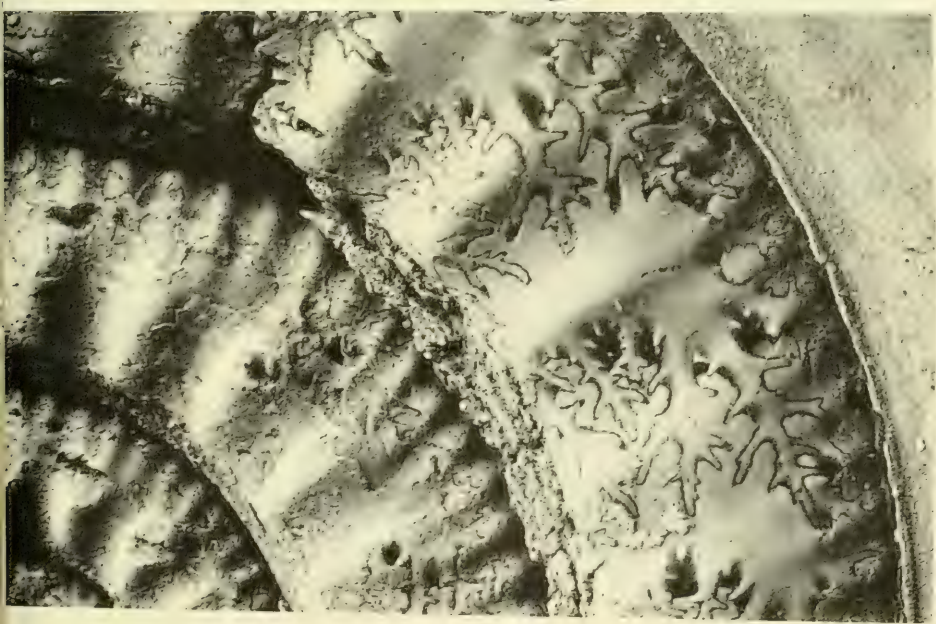
Natural size if not otherwise indicated.

Figure		Page
a-b.	Docidoceras (Docidoceras ?) sp. aff. <i>D. longalvum</i> (Vacek)	134
	Kialagvik Formation, <i>S. sawerbyi</i> Zone, lower <i>Pseudocidoceras</i> zonule, Wide Bay. Internal mold of phragmocone and part of body chamber; b, enlarged (X 3) upper right sector of fig. a, showing umbolateral groove and porous filling material. (Inner whorls and ventral views of same specimen on Pl. 32, figs. 5a-c). Loc. WA 10 at 8m. McM J 937.	



a

b x3

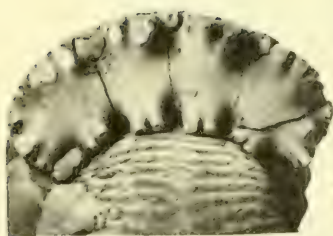




1a



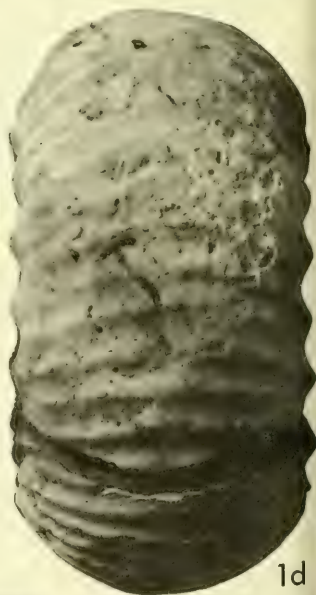
1b



2



1c



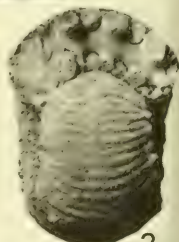
1d



3a



3b



3c

EXPLANATION OF PLATE 34

Natural size if not otherwise indicated.

Figure		Page
1-3c.	Docidoceras (Pseudocidoceras) widebayense	
	Westermann, n. sp.	137
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule, Wide Bay. 1a-d. Holotype, complete internal mold; 1c, body chamber removed. Loc. USGS 21252. USNM 160239. 2. Septum near end of phragmocone. Loc. WA 13 at 13-16m. McM J 899. 3a-c. Complete internal mold except for aperture; 3c-d, last 1 1/2 whorls removed. Loc. WA 13 at 13-16m. McM J 897.	

EXPLANATION OF PLATE 35

Natural size if not otherwise indicated.

Figure

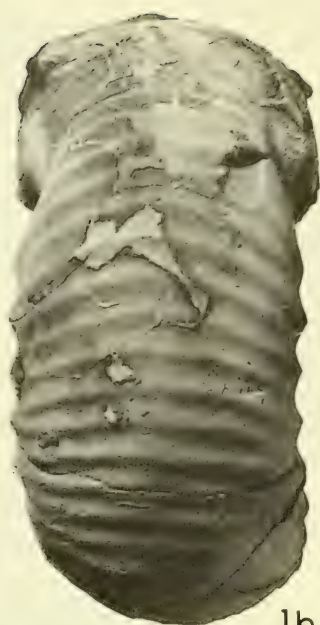
Page

1-2d. **Docidoceras (Pseudocidoceras) widebayense**

- Westermann, n. sp. 137
 Kialagvik Formation, *S. sowerbyi* Zone, *Pseudocidoceras* zonule,
 Wide Bay. 1a-b. Almost complete internal mold with aperture.
 Loc. WA 10 at 11m. McM J 917. 2a-d. Complete internal
 mold with aperture; 2c-d, body chamber removed. Loc. WA
 13 at 9m. McM J 896.



1a



1b



2a



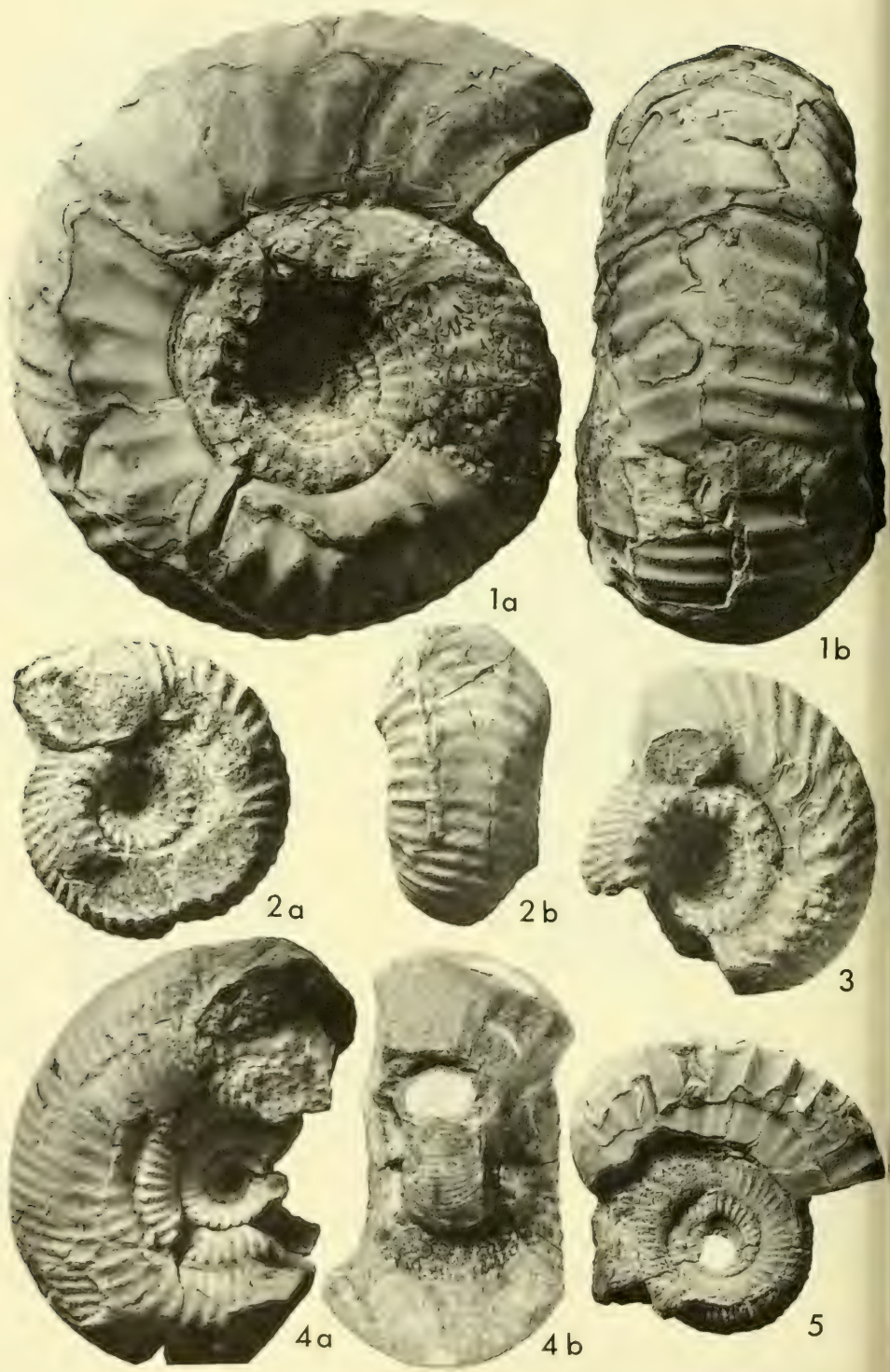
2b



2c



2d



EXPLANATION OF PLATE 36

Natural size if not otherwise indicated.

Figure		Page
1a-b.	Docidoceras (Pseudocidoceras) widebayense Westermann, n. sp.	137
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, (lower) <i>Pseudocidoceras</i> Zonule, Wide Bay. Complete internal mold except for aperture. Loc. USGS 19862. USNM 16025.	
2, 3.	Docidoceras (Pseudocidoceras ?) sp. aff. D. widebayense Westermann, n. sp. [♂ ?]	147
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule, Wide Bay. 2a-b. Damaged small internal mold with some test remains and aperture. Loc. WA 10 at 6m. McM J 933. 3. Damaged small internal mold with aperture, possibly with lateral lappet. Scree of loc. WA 10. McM J 932.	
4, 5.	Docidoceras (Pseudocidoceras) n. sp. indet. A	151
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 4a-b. Damaged phragmocone and body chamber with aperture. Loc. USGS 12405. USNM 160251. 5. Somewhat crushed specimen with pathological body chamber fragment. Loc. USGS 19862. USNM 160252.	

EXPLANATION OF PLATE 37

Natural size if not otherwise indicated.

Figure

Page

- 1-5. **Docidoceras (Pseudocidoceras) cf. D. widebayense**
 Westermann, n. sp. 146
 Kialagvik Formation, *S. sawerbyi* Zone, *Pseudocidoceras* zonule,
 Wide Bay. 1a-b. Almost complete internal mold with test
 remains on phragmocone, with aperture. Loc. WA 13 at
 13-16m. McM J 928. 2a-b. Almost complete internal mold
 with one-half whorl of body chamber. Loc. WA 13 at 13-
 16m. McM J 927. 3a-b. complete, slightly damaged internal
 mold. Loc. USGS 19862, USNM 160253. 4a-b. Phragmocone
 with crushed body chamber and aperture. Loc. USGS 19801,
 USNM 160255. 5. Phragmocone with crushed body chamber
 and aperture. Loc. USGS 21252, USNM 160255.





EXPLANATION OF PLATE 38

Natural size if not otherwise indicated.

Figure		Page
a-c.	Docidoceras (Pseudocidoceras) camachoi	
	Westermann, n. sp.	147
	Kialagvik Formation, <i>S. sawerbyi</i> Zone, Wide Bay. Holotype, complete internal mold with test remains. Probably loc. USGS 19862. USNM 160256.	

EXPLANATION OF PLATE 39

Natural size if not otherwise indicated.

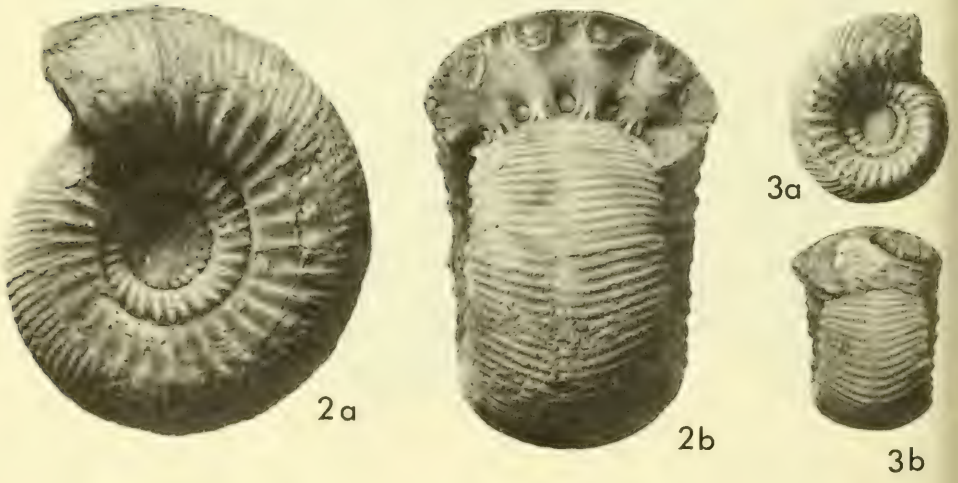
Figure

Page

a-b. **Docidoceras (Pseudocidoceras) camachoi**

Westermann, n. sp. 147
 Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. Complete
 internal mold with minor test remains and umbolateral groove
 with 'porous material.' Loc. USGS 19801, USNM 160257.





EXPLANATION OF PLATE 40

Natural size if not otherwise indicated.

Figure

Page

1-3b. **Docidoceras (Pseudocidoceras) camachoi**

Westermann, n. sp.

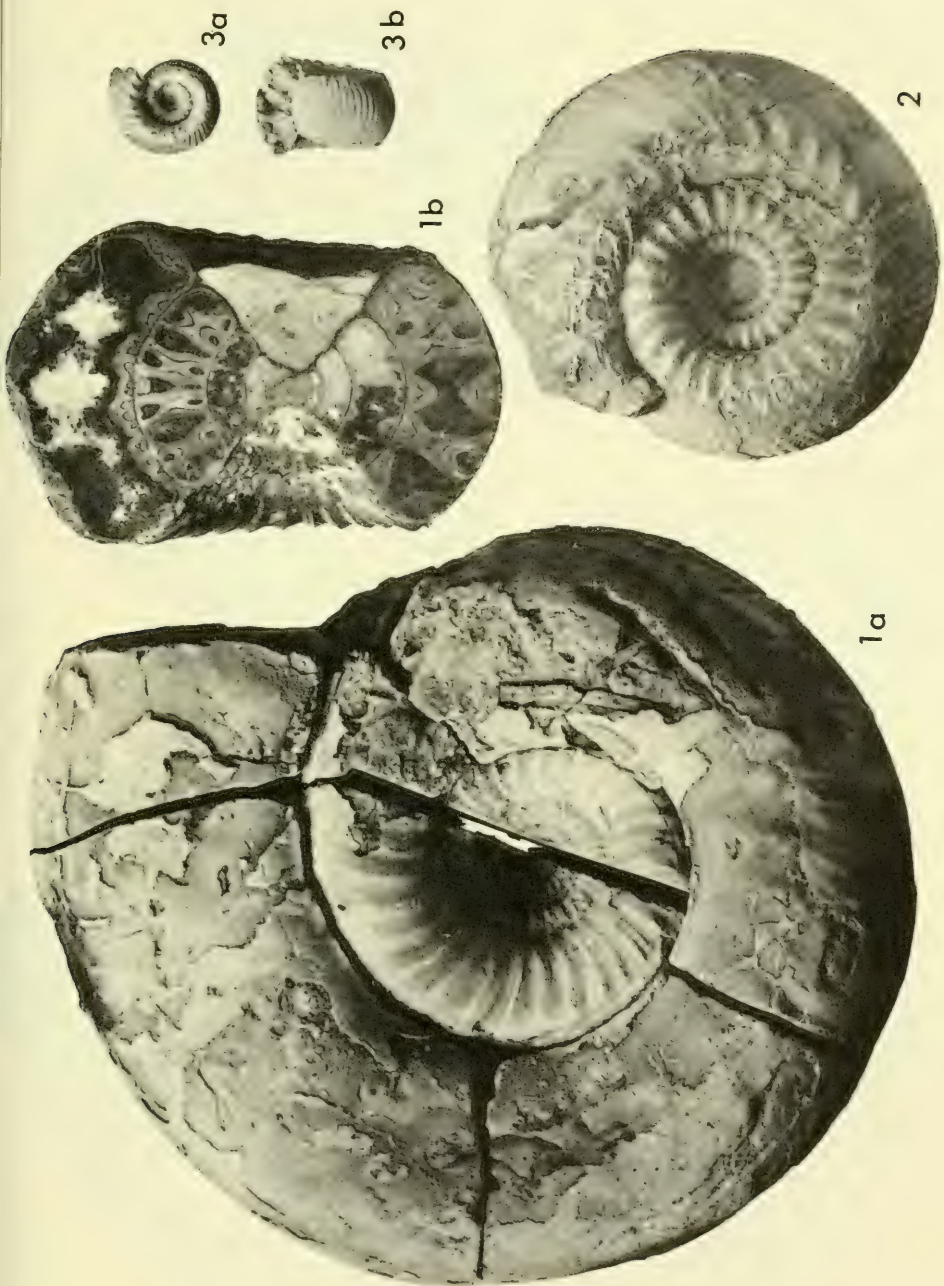
147

Kialagvik Formation, *S. sowerbyi* Zone, Wide Bay. 1a-b. Almost complete internal mold with pronounced umbolateral groove (on both sides), partly filled with 'porous material' and bridged by the shell. Loc. CAS 29011. CAS 13111. 2a-b. Internal mold of average phragmocone, Loc. USGS 12405, USNM 160258. 3a-b. Nucleus of phragmocone from the *Pseudocidoceras* zonule. Loc. WA 10 at 6-7.7m. McM J 921.

EXPLANATION OF PLATE 41

Natural size if not otherwise indicated.

Figure		Page
1-2.	Docidoceras (Pseudocidoceras) camachoi Westermann, n. sp.	147
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule, Wide Bay. 1a-b. Complete specimen except for aperture, phragmocone with test; 1b, cross section of phragmocone. Loc. USGS 21251. USNM 160259. 2. Relatively small, incom- plete internal mold with test remains and weak umbolateral groove. Loc. WA 10 at 1.8m. McM J 923.	
3a-b.	Docidoceras (Pseudocidoceras) cf. D. camachoi Westermann, n. sp.	148
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Nucleus of phragmocone, internal mold. Loc. USGS 12405, USNM 160260.	





EXPLANATION OF PLATE 42

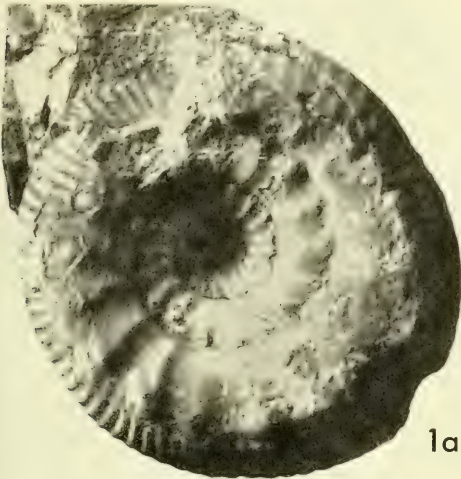
Natural size if not otherwise indicated.

Figure		Page
1a-b.	Docidoceras (Pseudocidoceras) camachoi Westermann, n. sp.	147
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Almost complete internal mold with aperture and minor test remains;	
	1b. penultimate phragmocone whorl. Loc. CAS 29011. CAS 13121.	
2.	Docidoceras (Pseudocidoceras ?) cf. D. camachoi Westermann, n. sp.	151
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. Complete internal body chamber mold, with damaged phragmocone. Loc. CAS 29011, CAS 13120.	

EXPLANATION OF PLATE 43

Natural size if not otherwise indicated.

Figure		Page
1a-b.	Docidoceras (?) [? Pseudocidoceras or n. subg.], n. sp. indet. B	151
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, base of <i>E. amplexens</i> zonule, Wide Bay. Phragmocone with crushed beginning of body chamber, largely with test. Loc. WA 3. McM J 930.	
2a-b.	Docidoceras ? (Pseudocidoceras ?) paucinodosum Westermann, n. sp.	153
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexens</i> zonule, Wide Bay. Holotype, complete internal mold with aperture; 2b $\times$ 1.1 (see also Pl. 44, fig. 1). Loc. CAS 29014. CAS 13123.	



1a



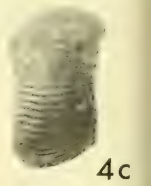
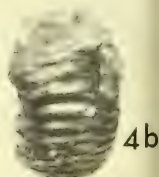
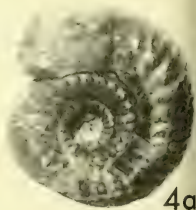
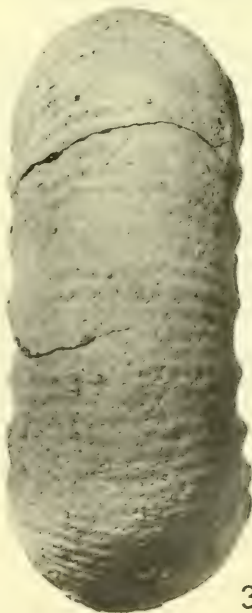
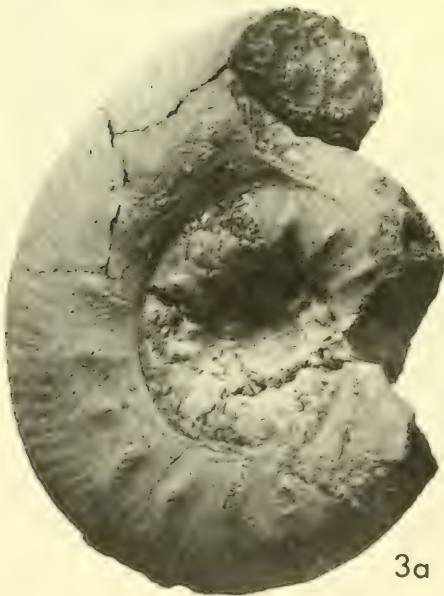
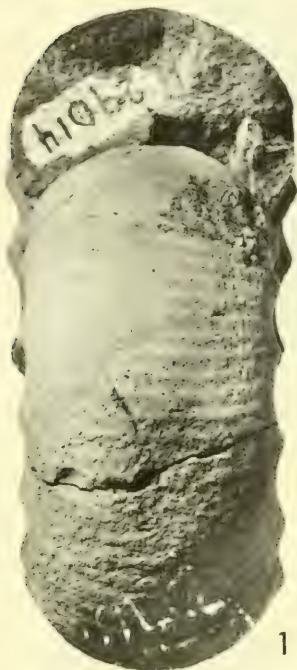
1b



2a



2b



EXPLANATION OF PLATE 44

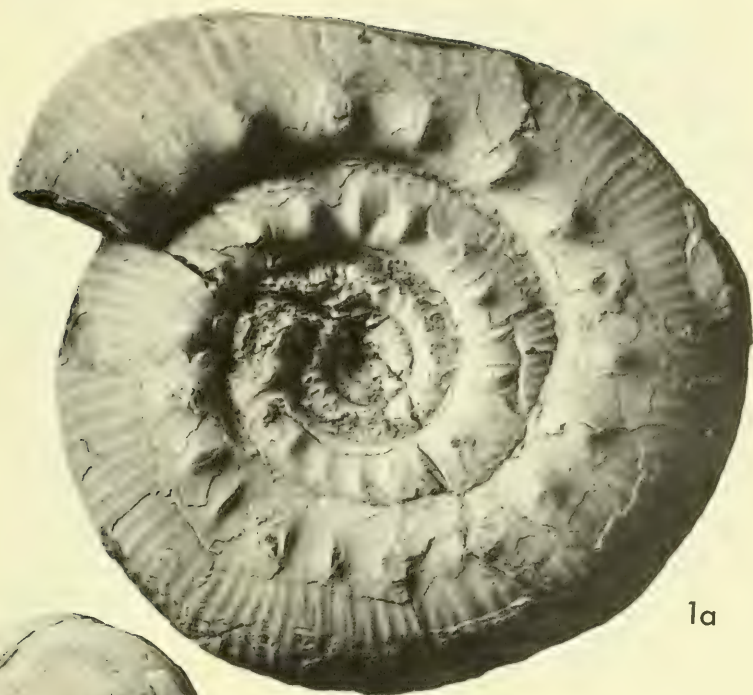
Natural size if not otherwise indicated.

Figure	Page
1-3b. Docidoceras? (Pseudocidoceras ?) paucinodosum Westermann, n. sp.	153
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexans</i> zonule, Wide Bay. 1. Holotype (see Pl. 43, figs. 2a-b). 2. Complete but partly crushed internal mold, with shallow umbolateral groove filled by test. Loc. WA 5, McM J 934. 3a-b. Almost complete, slightly deformed internal mold. Loc. USGS 19828. USNM 160261.	
4a-c. Docidoceras? (Trilobiticeras ?) n. sp. indet. ♂	155
Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>E. amplexans</i> zonule, Wide Bay. Complete but partly deformed internal mold with test remains and large lateral lappet. Loc. Shell L 546. Collec- tions of Shell Oil Co.	

EXPLANATION OF PLATE 45

Natural size if not otherwise indicated.

Figure		Page
1, 2.	Pseudotoites cf. P. argentinus Arkell	158
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, Wide Bay. 1a-b. Almost complete internal mold with damaged body chamber and minor test remains. Loc. USGS 19922. USNM 160262.	
	2. Partly crushed phragmocone. Loc. USGS 12405, USNM 160263.	



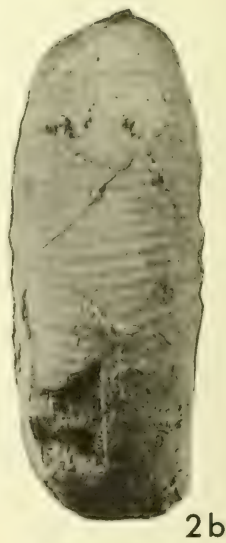
1a



1b



2



EXPLANATION OF PLATE 46

Natural size if not otherwise indicated.

Figure		Page
1-2b.	Pseudotoites cf. P. argentinus Arkell	158
	Kialagvik Formation, <i>S. sowerbyi</i> Zone, <i>Pseudocidoceras</i> zonule. Wide Bay. 1a-b. Phragmocone with crushed fragment of body chamber; 1b, polished section. Loc. WA 13w at c.18m. McM J 935. 2a,b. Phragmocone with damaged beginning of body chamber. Loc. WA 10 at 11m. McM J 938.	

EXPLANATION OF PLATE 47

Natural size if not otherwise indicated.

Figure		Page
a-c.	Pseudotoites cf. P. transatlanticus (Tornquist) Kialagvik Formation, <i>S. sowerbyi</i> Zone, lower <i>Pseudocidoceras</i> zonule, Wide Bay. Complete internal mold, other side dam- aged; a $\times 0.8$, b-c $\times 1.1$; showing umbolateral groove and section. Loc. USGS 19862, USNM 160264.	162



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By

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NEW MIDDLE JURASSIC AMMONITINA FROM NEW GUINEA

G. E. G. WESTERMANN AND T. A. GETTY

ABSTRACT

The Lower Bajocian to Middle Callovian Ammonitina of an unlocalized collection from the Kemaboe Valley of West Irian (formerly West or Dutch New Guinea) is described; several uppermost Jurassic to basal Cretaceous ammonite species of the same collection are recorded only. Most of the species and genera are either new to the Indo-Malayan Archipelago or have previously been wrongly classified. *Docidoceras* s.s., *Stephanoceras* s.s., *Bullatimorphites* (*Treptoceras*), and *Cobbanites* (?) are new to the entire Southeast Asia-Australia area.

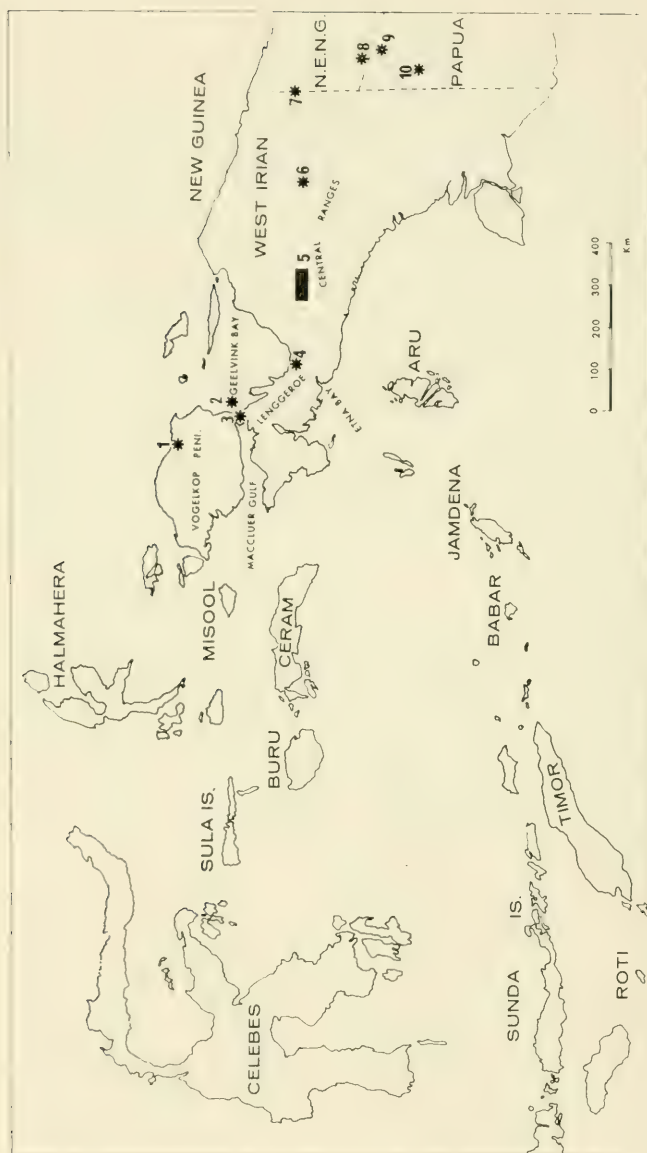
The Lower Bajocian (*Sonninia sowerbyi* Zone) is clearly indicated by the Mediterranean *Docidoceras* (*Docidoceras*) *longalvum* (Vacek) showing close affinity to the Anatolian subspecies *D. limatum* (Pompeckj), and by *Fontannesia* sp. with affinity to the West Australian *F. clarkei* (Crick) and possibly being identical with '*Grammoceras*' *kiliani* (Kruizinga) from the Sula Islands in the Moluccas. Middle Bajocian is represented by the almost cosmopolitan *Stephanoceras* ex gr. *S. humphriesianum* (Sowerby) and by the probably endemic species *S. (Stemmatoceras?) etheridgei* (Gerth), possibly present in both dimorphs. The presence of *Bullatimorphites* (*Treptoceras*) aff. *B. uhligi* (Popovici-Hatzeg) and (?) *Cobbanites* aff. *C. engleri* (Frebold) suggests Upper Bathonian age or Lower Callovian age, and affinities with Europe-Western Asia and the northern Cordilleras respectively. Early Middle Callovian is clearly indicated by the 'Indic' *Subkossmatia* and *Eucycloceras* (?). Curiously enough, the usually ubiquitous *Macrocephalites* s.l. assemblage of the Lower Callovian is missing.

The unnamed new subgenus of *Bullatimorphites* ?, including *B. costidensus*, n. sp., and the associated *Irianites*, n. gen., based on the much discussed '*Coeloceras*' *moermanni* Kruizinga from the Sula Islands, are probably Callovian and possibly Middle Callovian in age; it is suggested that *Bullatimorphites* ? (n. subgen.) is phylogenetically intermediate between true *Bullatimorphites* (Middle Bathonian to Lower Callovian) and the eucycloceratids, particularly *Subkossmatia* (Middle Callovian). The family Macrocephalitidae as defined in the 'Treatise,' by the same token, would then be of polyphyletic origin, including the macrocephalitids proper which evolved from sphaeroceratids, as well as the eucycloceratids. The Eucycloceratidae Spath are, therefore, provisionally again separated, at least at the subfamily level.

The previous finds of Bajocian to Callovian Ammonitina in New Guinea and the Indonesian archipelago are re-examined.

INTRODUCTION

Like all previous ammonite collections from New Guinea, the fossils under study were obtained *ex situ* from stream bed and river bed pebbles of more or less worn and broken concretions. Consequently, no stratigraphic evidence is available; however, one important faunal association is known: a single fragment of a concretion contained *Irianites* cf. *I. moermanni* (Kruizinga) and *Bullatimorphites* ? (*Treptoceras* ?) *costidensus*, n. sp. Unfortunately, the other fossils before reaching us had already been removed from the concretions and segregated without indicating associa-



Text-fig. 1.—Index map of eastern Indonesia and western New Guinea, showing principal Jurassic ammonite collecting sites in New Guinea. 1. Wairori River, 2. Roemberpon Island, 3. Windesi, 4. South Geelvink Bay, 5. Kemaboe Valley (black rectangle; described herein), 6. Aramaroi River, 7. Sepik River, 8. Telefomin, 9. Strickland Gorge, 10. Observatory Bend.

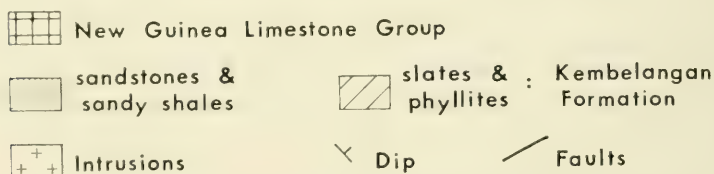
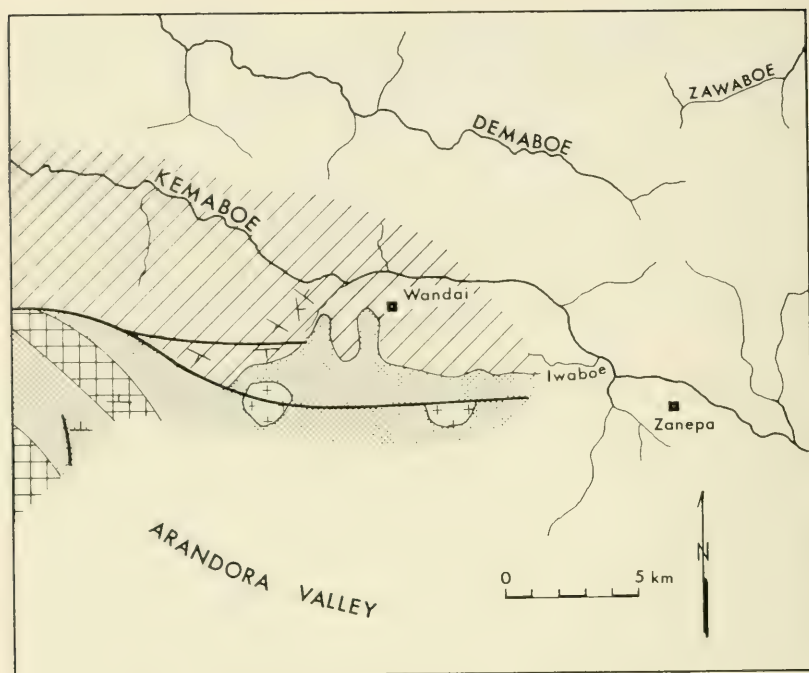
tions. Nevertheless, this collection of largely new or hitherto obscure forms from the important but little known southeast Asian archipelago is judged worthwhile to be published. The ammonites described herein represent the majority of a collection made in the course of an ethnological expedition by Dr. C.C.F.M. Le Roux during 1939-1940 to the region of the Kemaboe Valley in the Central Ranges of central West Irian (formerly West New Guinea or Netherlands New Guinea) (Text-figs. 1,2). Probably all of the fossils were obtained along the bed of the Iwaboe River, a left tributary of the Kemaboe entering about four kilometers below Zanepa.

The complete collection, permanently stored at the Rijksmuseum van Geologie en Mineralogie (R.G.M.) in Leiden, The Netherlands, comprises approximately 270 ammonites, many fragmentary, of which more than 200 were sent to us and the remainder briefly studied in the Leiden collections. All are preserved in black calcareous mudstone containing variable amounts of free calcite and disseminated pyrite, together with some silica, in a matrix of the same material. This mode of preservation was noted by Boehm (1913) in ammonites from Windesi, northern Lenggroe area (Text-fig. 1, loc. 3) but with the difference that the silica was a more prominent constituent of the concretions. The state of preservation of the material is good although in some cases the inner whorls have been crushed on one side or, more rarely, destroyed. Some whorls have been partly crushed and a few have been compressed dorso-ventrally. Exposed whorls have also suffered from transportation.

In August 1968, G. Westermann studied the main Jurassic ammonite collections from Indonesia (including West Irian) during a brief visit to the following institutions in The Netherlands: Rijksmuseum van Geologie en Mineralogie, Leiden; Mineralogical and Geological Museum, University, Delft; Geological Institute, University, Amsterdam; and the Royal Shell Exploration Production Laboratory in Rijswijk near Den Haag.

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For the loan of the collection and of several holotypes we thank Miss G. E. de Groot and Mr. W. U. Boon van Strein of the Rijksmuseum van Geologie en Mineralogie in Leiden. For their



Text-fig. 2. — Geotectonic map of the Kemaboe Valley area (after Visser and Herbes, 1962). The limestones belong to the New Guinea Limestone; the sandstones to sandy shales and slates and phyllites belong to the Kembelangan Formation.

help during the visit of G. Westermann, we also thank Mr. Schuif of the Museum van Mineralogie en Geologie in Delft, Professors J. J. Hermes and H. J. MacGillavry of the Geologisch Instituut, University of Amsterdam, and Dr. R. Lagaij from the Bataafsche Internationale Petroleum Maatschappij N. V. in Rijswijk. Dr. M. van den Boogaard of the Geological Institute Amsterdam furnished photographs of type specimens. Comparative fossil material and plastotypes were made available by Dr. J. Sornay, Muséum

National d'Histoire Naturelle, Paris, Drs. D. McLaren and H. Frebold of the Geological Survey of Canada, Ottawa, and Dr. R. Jordan of the Niedersächsisches Landesamt für Bodenforschung, Hannover, Germany. Important discussions were contributed by Dr. J. Callomon from the University of London and Drs. R. Enay and C. A. Mangold from the University of Lyon. This project was supported by a grant of the National Research Council of Canada.

STRATIGRAPHY OF THE KEMABOE VALLEY AREA

Although forming one of the major east-west valleys in central New Guinea, the Kemaboe Valley (Text-fig. 2) has remained poorly known, largely because of the surrounding rugged terrain and dense forests; it is not shown on the geological map of Indonesia prepared by the Direktorat Geologi Indonesia and published by the United States Geological Survey in 1965 but on the maps published by the Netherland Nieuw Guinea Petroloeum Maatschappij (referred to hereafter as the N.N.G.P.M.) (Visser and Hermes, 1962). The lower course of the Kemaboe is unknown, but it is presumed to enter one of the tributaries of the Waipoga, which empties into the eastern side of Geelvink Bay.

According to Visser and Hermes (1962), the thick, coarse and fine clastics with minor carbonate are placed in the Kembelangan Formation, comprising Jurassic and Cretaceous, which is most fully developed in the Lenggeroe area southwest of Geelvink Bay (Text-fig. 1). Here it comprises the 'A', 'B', 'C', and 'D' members with 'B', 'C', and 'D' forming a sequence in an upward succession of which 'A' is, at least partly, the lateral equivalent. The 'A' and 'C' members are predominantly argillaceous, while the 'B' and 'D' members are predominantly arenaceous. The 'B', 'C' and 'D' members are restricted to the southwestern Lenggeroe area west of the Jakarta Fault Zone, while the 'A' member occurs only east of it.

The 'A' member consists of about 1200 m shales and mudstones, with intercalated limestone bands and massive limestones at the base, but becomes progressively metamorphosed eastward passing into schists and phyllites. Fossils are not common at the type locality (Nanggoebi Valley), but along the strike, both to the north and south, concretions derived from this member have yielded numerous ammonites indicating Bajocian, Bathonian ?, Callovian, and Tithonian (Boehm, 1913; Visser and Hermes,

1962). North of the Lenggeroe area the 'A' member is overlain with apparent disconformity or, more probably, with fault contact, by the pelagic limestones of the Upper Cretaceous Imskim Formation, apparently suppressing the upper part of the 'A' member. This was supported by the discovery of Lower Cretaceous ammonites in the 'A' member in the Central Ranges by Gerth (1965). The 'B', 'C', and 'D' members were originally described from a well at Etna Bay where 'B' consists of approximately 600 m sandstone, becoming argillaceous above and overlying the nonmarine Tipoema Formation. The lower part is of Upper Bajocian to Lower Oxfordian age [based on *Grammatodon virgatus* (J. de C. Sowerby)] and has been correlated with the 'A' member while the upper argillaceous sandstones, the 'B' member proper, contains Lower Cretaceous Foraminifera.

The superposed 'C' member consists of approximately 700 m grey shales and silty shales, with thin sandstones. The foraminiferal fauna indicates Lower Cretaceous, below, and Upper Cretaceous, above.

The overlying 'D' member is another sandstone unit, about 150 m thick, also containing Upper Cretaceous Foraminifera, which is overlain by Cenozoic limestones, but may locally reach upward into the Cenozoic.

The 'A' member is, therefore, the eastern equivalent of at least most of the 'B' member.

Outside the Lenggeroe area, the Kembelangan Formation has only been divided into the argillaceous-arenaceous undifferentiated 'BCD' members bearing Jurassic ammonites, and the argillaceous 'A' member, also bearing Jurassic fossils. The consistently more southward location of the arenaceous facies suggests a southern source of the clastics.

Both facies of the Kembelangan Formation are developed in the Kemaboe Valley area. The 'A' member consists of more than 1000 m intensely folded soft black slates and phyllitic slates, with intercalations of black marly limestones, silty sandstones and orthoquartzites; the base is unknown. The beds show a progressive increase in metamorphism to the north and northwest, while to the south they are overlain, apparently partly with fault contact and partly with disconformity, by the sandstones and sandy shales of the undifferentiated 'BCD' members. Southwest of the Kemaboe

TABLE I — Westermann

STAGE	Etheridge, 1890 (Strickland River; loc. 10)	Boehm, 1913 (W. Lenggeroe; loc. 3)	Gerth, 1927 (?Vogelkop Peni.; loc. 1)	Visser & Hermes, 1962 (Roemberpon I. & Lenggeroe; loc. 2,4)	Westermann & Getty (Kemaboe Valley; loc. 1)
U.					
M. CALLOVIAN		<i>Subkossmatia obscura boehmi</i> n. subsp. — Pl. V, fig. 2 <i>S. (?)</i> — ?Pl. III, fig. 4; Pl. IV, fig. 4. ? <i>Eucycloceras intermedium</i> Spath — Pl. IV, fig. 3 <i>Idiocycloceras ?</i> — Pl. IV, figs. 2, 3		? <i>Idiocycloceras</i> cf. <i>I. bifurcatum</i> (Boehm) — fig. 30 <i>Irianites moermanni</i> (Kruiz.) ♂ — fig. 24 —	? <i>Subkossmatia obscura boehmi</i> n. subsp. ? (?) <i>Eucycloceras intermedium</i> Spath <i>Irianites moermanni</i> (Kruiz.) ♂ & (?) ♀ —
L.	<i>Macrocephalites</i> (' <i>Kamptcephalites</i> ') <i>etheridgei</i> Spath ♂ — fig. 4 <i>M. ('Dolikephalites')</i> <i>flexuosus</i> Spath (♂ ?) — fig. 5	<i>Macrocephalites</i> (' <i>Dolikephalites</i> ') cf. <i>M. kecuensis</i> Boehm ♂ — Pl. IV, fig. 1, ?5; Pl. V, ?fig. 1 <i>Holcophylloceras mamapiricum</i> (Boehm) — Pl. I, fig. 3		<i>M. ('Dolikephalites?')</i> <i>kecuensis</i> Boehm — fig. 28 <i>M. ('Pleurocephalites?')</i> sp. — fig. 31 (?) <i>M. ('Kamptcephalites')</i> sp. — figs. 26, 33, 34, ?19	<i>Bullatimorphites</i> (<i>Treptoceras</i>) aff. <i>B. uhligi</i> — 11 <i>B. (?)</i> (<i>T. ?</i>) aff. <i>B. microstoma</i> (Crick) <i>B. ?</i> (<i>T. ?</i>) <i>costidensu</i> n. sp. <i>B. ?</i> (<i>T. ?</i>) n. sp. A ♂ <i>B. ?</i> n. sp. ♀
BATHONIAN		[? <i>Tulites godohensis</i> (Boehm) — p. 10] [<i>Cadomites?</i> ex. gr. <i>C. rectolobatus</i> (Hauer) — p. 10]	<i>Bullatimorphites</i> (<i>Treptoceras</i>) aff. <i>B. uhligi</i> (Pop. - Hatz.) ♂ — p. 226	?	? (?) <i>Cobbanites</i> aff. <i>C. engleri</i> (Frebold)
U.		<i>Chondroceras?</i> (<i>Praetulites</i>) <i>kruizingai</i> Westermann — Pl. II, fig. 3			
M. BAJOCCAN (ss.)	<i>Stephanoceras s.l.</i> — fig. 2	<i>Stephanoceras s.l.</i> — Pl. V, fig. 4 <i>S. (Stemmatoceras)</i> cf. <i>S. palliseri</i> (McLearn) ♀ — Pl. 3, fig. 2, Text-fig. 3 <i>Chondroceras</i> (<i>Defonticeras?</i>) <i>boehmi</i> Westermann — Pl. 2, fig. 4	<i>S. (Stemmatoceras)</i> <i>etheridgei</i> (Gerth) ♀ — Pl. 36, fig. 1 " <i>Itinsaites</i> " aff. <i>mackenzii</i> McLearn ♂ — Pl. 36, fig. 2	<i>Stephanoceras</i> (<i>Toloceras</i>) cf. <i>S. itinsae</i> (McLearn) ♀ — fig. 20 <i>S. (Stemmatoceras)</i> cf. <i>S. etheridgei</i> (Gerth) ♀ — figs. 16, 19 " <i>Itinsaites</i> " cf. <i>itinsae</i> McLearn ♂ — fig. 25 <i>S. (Stemmatoceras)</i> cf. <i>S. frechi</i> (Renz) ♀ — fig. 21 <i>S. (Stephanoceras)</i> sp. — fig. 22	<i>Stephanoceras</i> (<i>Stephanoceras</i>) aff. <i>S. lamph...</i> (?) <i>S. (Stemmatoceras)</i> <i>etheridgei</i> (Gerth) ♀ & ? ♂ [?" <i>Itinsaites</i> "]
L.				<i>Pseudotoites</i> (<i>Latotoites</i>) cf. <i>P. woodwardi</i> (Crick) — fig. 17 <i>Pseudotoites</i> sp. — fig. 18	<i>Docidoceras</i> (<i>Docidoceras</i>) <i>longulum</i> cf. <i>limatum</i> (Pon.) <i>Fontannesia</i> aff. <i>F. clarkii</i> (Crick) [subsp. <i>kiliani</i> (Kruiz.)

Valley (near Wissel Lakes) this arenaceous unit contains Upper Cretaceous Foraminifera. As in the Lenggroe area, incompetent upper 'A' beds appear to have been tectonically suppressed, both facies are separated by a fault zone (here the North Paniai Fault Zone), and the more argillaceous beds to the northeast are thicker than the arenaceous beds to the southwest. There would seem to be a possibility that the depositional environment of the Kembelangan Formation was tectonically controlled during Jurassic and Cretaceous times.

PALEONTOLOGY

PREVIOUS LITERATURE ON BAJOCIAN-CALLOVIAN AMMONITES

Jurassic ammonites have been recorded and figured from a number of localities in western and central New Guinea (Text-fig. 1). The literature was reviewed particularly by Arkell (1956) and Visser and Hermes (1962), and a revised account of most specimens figured up to date from the Bajocian to Callovian is given here in table form (Table 1). The important early descriptions by Etheridge (1890) and especially by Boehm (1913) were taxonomically revised by Spath (1928) in the course of his work on the ammonites of Kutch, India, and by Westermann (1956 a,b). The Bajocian to Callovian ammonites figured give good evidence for only the earlier Callovian and Middle Bajocian (*s.s.*), because Boehm's figured fragment of a '*Stephanoceras daubenyi*' (pl. 3, fig. 1) cannot be clearly identified with *Cadomites* sp. However, the subgenus *Chondroceras?* (*Praetulites*) Westermann which was based on "*Sphaeroceras godohense* Boehm" Kruizinga, *non* Boehm, from the Sula Islands and New Guinea, has recently been described from the Upper Bajocian *P. parkinsoni* Zone of the Venetian Alps (Sturani, 1964 a,b). The holotype of *Stephanoceras* (*Stemmatoceras?*) *etheridgei* Gerth (1927) is here refigured (Text-fig. 8). The fragment figured under the same name (*op. cit.*, fig. 2), however, is a microconchiate *Stephanoceras s.l.*, probably of the subgenus *Itinsaites*. Gerth's (p. 226) "*Sphaeroceras cf. bullatum* d'Orb.", which is here figured (Text-fig. 10), is close to the European *Bullatimorphites* (*Treptoceras*) *uhligi* (Popovici-Hatzeg). The small collection of ammonites recorded but not figured by Martin (1911; see also Visser and Hermes, 1962, p. 54) was re-studied in the Rijksmuseum of Leiden. The "*Quenstedtoceras?*"

(p. 97) from the Digoel River (st. 12117) is probably a macrocephalitid and the "*Macrocephalites*?" from B-River (p. 95), a *Bullatimorphites*? macroconch. Schlüter's (1929) collection from the Sepik River (loc. 7) contained the early Callovian "*Macrocephalites keeuwensis* γ" Boehm besides the more abundant Upper Jurassic ammonites. Arkell and Donovan, respectively identified (in Visser and Hermes, 1962) a smaller collection from Roemberpon Island (Text-fig. 1, loc. 2) and a larger collection from claystone concretions in riverbeds between Geelvink and Etna Bays in the southeastern Lenggroe Area (loc. 4); added to the previously described forms were the circumpacific genus *Pseudotoites* and the poorly known 'Normannites' *moermannii* (Kruizinga) which was originally placed in *Coeloceras* and is here redescribed and placed in the new genus *Irianites*. The figured specimens were re-studied at the Shell Company in Rijsvijk and partly given on loan. The taxonomic revision concerns particularly the fragments (Text-fig. 3) of supposed Upper Bajocian "*Baculatoceras*" sp. [= *Garantiana*] (Visser and Hermes, encl. 17, figs. 23 a,b) which is here identified with the Tithonian to Berriasian *Blanfordiceras novaguinense* Gerth (1965), a close ally (?subsp.) of the Himalayan *B. wallichii* (Gray); and the merely recorded Bajocian "*?Labyrinthoceras* sp." (*op. cit.*, p. 55) which is a typical Callovian *Subkossmatia*. The most recent description of ammonites from the Central Ranges (loc. 6) by Gerth (1965) includes besides Upper Jurassic to Berriasian forms only the record of "*Macrocephalites keeuwensis*" Boehm.

SYSTEMATIC DESCRIPTIONS

Superfamily **HILDOCERATACEAE** Hyatt, 1867

Family (?) **HILDOCERATIDAE** Hyatt, 1867

Subfamily (?) **GRAMMOCERATINAE** Buckman, 1905

Genus **FONTANNESIA** Buckman, 1902

Fontannesia aff. **F. clarkei** (Crick), 1894 [*F. clarkei* ssp. *kiliani* (Kruizinga), 1926] Pls. 48,49, Text-figs. 4-5

?1926. *Grammoceras kiliani* n. sp., Kruizinga (Sula Is.), Jb. Mijnwezen, vol. 54, p. 33, pl. 1, fig. 2.

Material. — Four large and two small, almost complete specimens with body chambers; one good phragmocone; one large phragmocone fragment, and one small body chamber with crushed phragmocone from Kemaboe Valley.

Occurrence. — West Irian, Misol and (?) Sula Islands.

Description. — The inner whorls are subquadrate to somewhat subrectangular, with gently rounded flanks and a flattened venter bearing a blunt keel. There are dense, often somewhat fasciculate and prosoradiate ribs, sometimes irregular in strength but without tubercles.

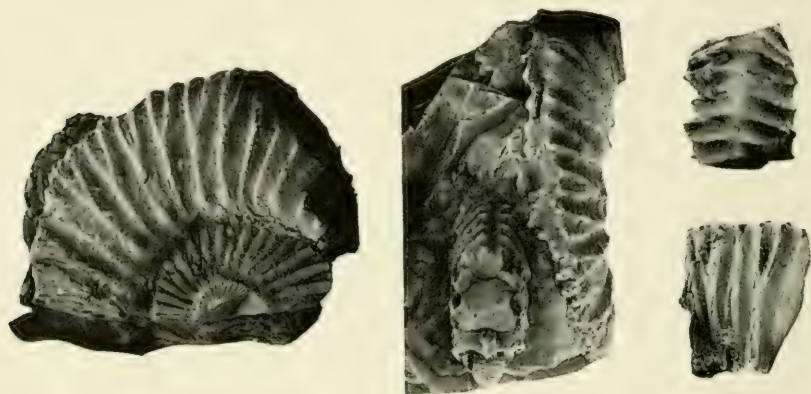
The intermediate whorls become compressed rounded subrectangular, usually developing a narrow, moderately steep umbilical slope, poorly separated from the flattened flanks, and distinct shoulders on which the strongly projected rib endings may form ventro-lateral 'carinae'. The venter is more or less broadly tabulate with strong blunt keel and, at least on the internal mold, frequently bisulcate. The ribs remain usually dense, rarely fasciculate, and straight to prosoradiate, with projection on the shoulders, leaving narrow smooth bands on umbilical slope and venter.

The outer one or two whorls are usually subrectangular with rounded umbilical slope, flat flanks and tabulate-unicarinate venter which at the end of the body chamber may become weakly bisulcate or slightly fastigate. The keel is prominent but blunt and 'solid' (unfloored) throughout. The umbilicus is shallow and only moderately wide ($U=32-38\%$). The costae may remain dense and more or less straight (Pl. 49, figs. 4 a,b), but usually become coarse and widely spaced, often slightly falcoid fasciculate or more rarely bifurcating and strongly projected on the outer flank and shoulder; dying out on the lowermost flank, the ribs reach their greatest strength on the uppermost flanks and on the shoulders where they may form a discontinuous 'carina.' The aperture was probably 'simple' with strongly projected rostrum or ventral lappet as suggested by a medium-sized specimen (Pl. 48, figs. 3 a,b).

As usual (Westermann, 1966), the more involute and compressed shells tend to be more densely and weakly costate than the more evolute and less compressed ones.

The septal suture (Text-fig. 4 a-c) is simple with subequal E/L and L/U bipartite saddles, moderately slender trifid L, much smaller raised U_2 followed at maturity by two almost straight much smaller umbilical elements (U_3 , U_4 part.) along a slightly sinking saddle line but ending at approximately the same radius. The internal part consists of a prominent I/U saddle and a much smaller saddle separated by a small oblique weakly bifid U_1 (?).

Classification of Fontannesia.—It is evident from the discussion above that the genus resembles the Grammoceratinae of the Hildoceratidae family more closely than the Sonniniidae in which it has been placed invariably. The principal reason for this classification of *Fontannesia* has undoubtedly been its stratigraphic occurrence in the *Sonninia sowerbyi* Zone where it is accompanied by the first “true” sonniniids, and the almost entire absence of the Hildoceratidae, except for the distinct *Tmetoceras* and the scarce *Asthenoceras* in the Aalenian of Europe (cf. Treatise, p. L 254). It

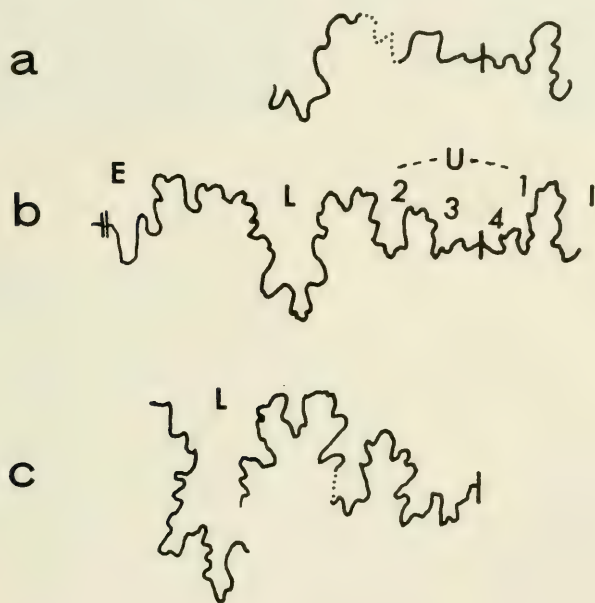


Text-fig. 3.—*Blanfordiceras wallichi novaguinense* Gerth (1917), newly developed specimen from South Geelvink Bay (loc. 4), previously figured under '*Baculatoceras* sp.' (Donovan, in Visser & Hermes, 1962, encl. 17, fig. 23). (Shell Research Lab., Utrecht, s.s. 215a) $\times 1$.

has been shown recently that the Grammoceratinae *Pseudolioceras* and *Asthenoceras* range abundantly into the Bajocian (s.s.) in the northeastern Pacific realm (Westermann, 1969b). It is probable that *Grammoceras* and *Pleydellia* continue well into the Aalenian in the same area (Frebold, 1960, pl. 12; Frebold, *et al.*, 1969, p. 31, pl. 1, figs. 16, 17; above first *Tmetoceras*). The stratigraphic bias against placing *Fontannesia* in the Grammoceratinae should be eliminated. Certainly the affiliation through descent of *Fontannesia* with *Grammoceras* s.l. can not seriously be doubted while the evolution of *Sonninia* s.l. from Hammatoceratidae is generally accepted. Thus, the Sonniniidae if retained as understood in the Treatise would be polyphyletic at the family level.

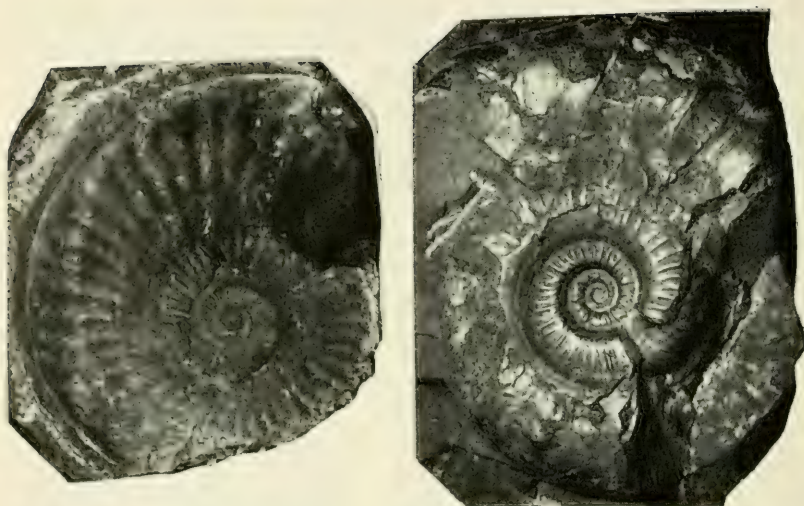
Comparison.—The species shows a similar wide range of ap-

parently continuous variation as is apparent in the European type species *F. grammoceroides* (Haug) and in the Australian *F. clarkei* (Crick). A large number of probable morphotypes of *F. grammoceroides* were described as several 'species' by Buckman (1892) from the *L. discites* Subzone of the Inferior Oolite of Bradford Abbas, Dorset. A similar series of forms of *F. clarkei* was figured by Arkell (*in* Arkell and Playford, 1954), probably including the morphotypes '*F. etheridgei* (Whitehouse)', '*F. fairbridgei* Arkell' and '*F. whitehousei* Arkell', which range from compressed weakly ornate to more inflated strongly ornate forms. *F. clarkei*, from the *S. sowerbyi* Zone of the Newmarracarra Limestone, is distinguished



Text-fig. 4. — Septal suture morphogeny of *Fontannesia* aff. *F. clarkei* (Crick) [? ssp. *kiliani* (Kruizinga)] from Kemaboe Valley, at whorl heights of (a) 5mm, (b) 12mm, and (c) 20mm. (R.G.M. Leiden, st. 12685).

from *F. grammoceroides* s.l. by the more prominent keel, which is set on a clearly tabulate or even slightly bisulcate venter and retained on the body chamber, by the more irregular often fasciculate and sometimes bifurcating ribs, and by the somewhat wider umbilicus with gentler slope; the relatively involute compressed variants of *F. clarkei* [*F. whitehousei*] agree in coiling with the rela-



Text-fig. 5. — Holotypes of (left) "*Grammoceras Kiliani*" Kruizinga (x1) and (right) "*Grammoceras Baumbergeri*" Kruizinga (x1.25); both from the Sula Islands. (Geol. Inst., Univ. Amsterdam, F. 9882 and F. 9883).

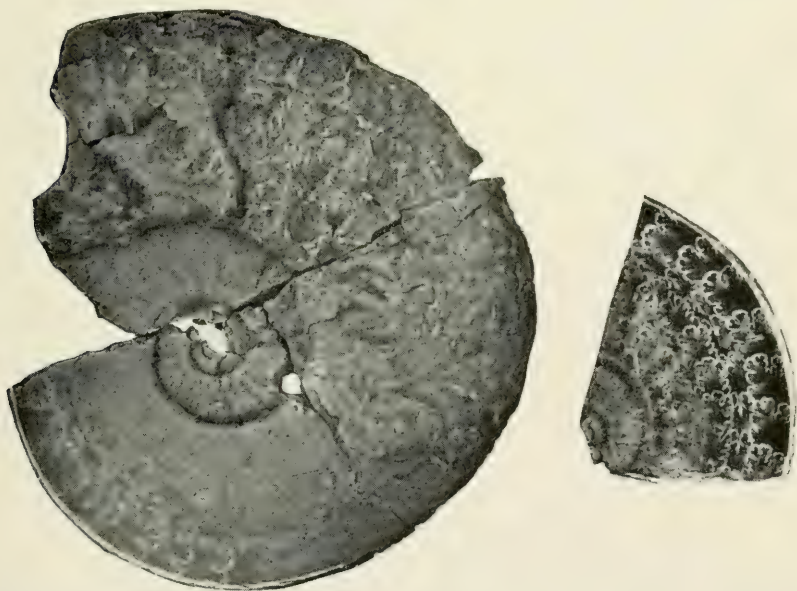
tively evolute variants of *F. grammoceroides*. Significantly, the 'fairbridgei' and 'whitehousei' morphotypes comprise only 4.5% and 12.14%, respectively, of the Australian sample.

The New Guinea species closely resembles *F. clarkei* s.l., in the ventral features and the irregular costae; however, it differs somewhat in the slightly smaller umbilicus and the more strongly projected costae which are more prominent on the shoulders and approach the keel more closely.

As already pointed out by Arkell (in Arkell and Playford, 1954, p. 567), the Sula Islands specimens described by Kruizinga (1926, pl. 1) under the new names of '*Grammoceras* baumbergeri', '*G. kiliani*' (here refigured Text-figs. 4,5) and '*Harpoceras* arietitiforme', resemble almost the Western Australia assemblage, except that '*G. kiliani*' is somewhat more involute than *F. clarkei* s.s. and '*H. arietitiforme*' is bisulcate. According to Kruizinga (1926, p. 39), the septal suture of '*G. kiliani*' differs strongly from that of *Grammoceras* in its higher complexity and the smaller external saddle; the suture is as in *Fontannesia*. All three names were based on single or a few incomplete specimens from *ex situ* concretions found as stream pebbles and their alleged Toarcian age is, therefore,

mere conjecture. The prominently tabulate-carinate to weakly bisulcate venter of these forms is also present in the fragmentary holotype of *Fontannesia clarkei* (refigured by Spath, 1939, pl. 2, fig. 16) and in the inner whorls of a topotype (*loc. cit.*, fig. 2).

The holotypes of '*G.* *kiliani*' and '*G.* *baumbergeri*' were re-investigated and are here refigured. The holotype of '*H.* *arietiforme*' however, appears to be lost. The holotype of '*G.* *baumbergeri*' is a fully grown specimen (55 mm diameter) with a three-quarters whorl long probably complete body chamber and approximated last few septa. The internal mold of the venter at 30 mm D is narrowly tabulate-carinate and was probably tricarinate on the shell. The simple septal suture is poorly preserved. The weak costation of the nucleus is fasciculate and somewhat irregularly tuberculate; on the intermediate whorls, the costae withdraw from the umbilical seam and become obsolescent on the relatively small body chamber. The septal suture drawn by Kruizinga (p. 40) is probably 'simplified' due to corrosion. The holotype of '*G.* *kiliani*', also an internal mold, is still incomplete at a diameter of approxi-



Text-fig. 6. — "*Harpoceras* sp." [= ? *Fontannesia* aff. *F. clarkei* (Crick)], from the "Dogger", west coast of Jefbie, Misol Archipelago. (Single specimen; Rijksmuseum Delft, 14903) x1.

mately 66 mm which includes part of the body chamber. The costation is similar but much stronger than on '*G.*' *baumbergeri*, somewhat fasciculate except for the ultimate half-whorl where the innermost flanks become smooth. Part of the Moluccas collection of Brouwer (which includes the type specimen of *Kruizinga*) which is in the Rijksmuseum van Mineralogie en Geologie in Delft, contained eight body chamber fragments and one almost complete specimen labeled '*Harpoceras* sp., Dogger,' from west coast of Jeffie, Misol Archipelago. The body chamber fragments, preserved as internal molds of grey limestone and varying from 18 to 28 mm in whorl height, resemble the holotype of '*G.*' *kiliani*, although the costae are generally more widely spaced. The single large specimen, strongly pyritized, with rather well-preserved phragmocone (70 mm D) and crushed one-half whorl incomplete body chamber, resembles '*G.*' *baumbergeri* in the strong compression and early loss of costation, which, in turn, is closely allied with *Fontannesia whitehousei* Arkell (1954), probably a variety of *F. clarkei* (Crick, 1894). The septal suture is well preserved in this specimen and closely agrees with those of the Australian form (Spath, 1939, Text-fig. 1; Arkell, 1954, pl. 29), being markedly more complex than shown in *Kruizinga's* (1926, p. 40) figure of '*G.*' *baumbergeri*. Affinity with early Bajocian *Fontannesia* is certainly closer than to any other known genus, and the Sula Island forms, '*G.*' *kiliani* and *G. baumbergeri*, are tentatively placed in this genus.

Of interest is also the occurrence of *Fontannesia* cf. *F. clarkei* in Turkey (Bremer, 1966, pl. 16, figs. 2 a,b), i.e. geographically much closer to the European occurrences of *Fontannesia*.

Most of the New Guinea forms resemble most closely '*Grammoceras*' *kiliani*, which is tentatively regarded as a subspecies of *F. clarkei*. The close affinity is evident by the presence in the Australian assemblage of relatively involute forms among the usually evolute and costate morphotype '*fairbridgei*' (Arkell, 1954, pl. 27, figs. 4,6).

Superfamily **STEPHANOCERATACEAE** Neumayr, 1875

Family **OTOITIDAE** Maseke, 1907

Genus **DOCIDOCERAS** Buckman, 1919

Docidoceras (Docidoceras) longalvum (Vacek) 1886, cf. subsp.

limatum (Pompeckj) 1897

Pl. 50, figs. 1 a-d

1886. *Cocloceras longalvum* Vacek (S. Alps), Abh. K.K. geol. Reichsanst., vol. 12, p. 99, pl. 17, figs. 1, 2.

1897. *Coeloceras limatum* Pompeckj (Anatolia), Z. deutsche geol. Ges., vol. 49, p. 745, pl. 31, fig. 5.
 1922. *Docidoceras perfectum* Buckman (England), 'Type Ammonites,' pl. 314.
 1925. *Coeloceras longulum* Vaček var. *trapanicum* Renz (Sicily), 'Monte San Giuliano (Monte Erice)', p. 30, pl. 1, fig. 6.

Material.—A single complete internal mold, with aperture and some test remains; inner whorls crushed on one side, from Kemaboe Valley.

Description.—The outer phragmocone whorls are strongly depressed sublenticular, with lateral edge at mid-flank, and loosely coiled, almost serpenticonic. The primaries are strong and rectiradiate, commencing directly at the umbilical seam and strengthening to small tubercles or, finally, weak bullae on the lateral edge. The secondaries, usually in threes with one or two attached weakly to a primary, are dense, blunt and weakly prosoradiate crossing somewhat convexly over the broad venter.

The body chamber, $1\frac{1}{4}$ whorl in full length, ceases width growth after about one-half whorl while height growth continues, the cross section thus becoming less depressed; the umbilical seam egresses gradually so that the aperture merely 'rides' on the preceding venter. The primaries, at first still somewhat bullae-like, weaken rapidly and retract from the umbilical seam. The secondaries become wider spaced and blunt, nearly dying out mid-ventrally at mid-length of the body chamber. Throughout the last one and one-half whorls, a prominent umbolateral groove is developed on the internal mold along the lower umbilical slope, filled with a porous, probably secondary shell material, and covered by the outer shell. This groove has recently been observed in a number of south Alaskan *Docidoceras* and *Pseudotoites* species where the 'porous material' was interpreted to serve the better attachment of the principle retractor muscle (Westermann, 1969b).

At the aperture is a simple oblique prominent flange or collar of strongly thickened test (4 mm) preceded by a constriction of the flanks on the internal mold only. The flange is partly visible on one side but better preserved on the mold. The septum is typically bullate with two complete (paired) saddle axes (E/L-I/U_n and L/U-U_n/U₁) closely resembling the topotype of Vacek (refigured: Westermann, 1964, pl. 6, fig. 2a). The suture is poorly preserved.

Comparison.—The specimen closely resembles '*Coeloceras*

limatum' Pompeckj (1897) from Anatolia (Turkey) which has recently been redescribed from the *L. discites* Subzone, *S. sowerbyi* Zone, of the same area (Bremer, 1966) in association with *Eudmetoceras* (*Euaptetoceras*) cf. *E. amplexans* (Buckman), *E. cf. dorsatum* (Merla) (pl. 15, figs. 2a,b), *Sonninia* (*Euhoploceras*) '*crassispinata*' Buckman [= *S. (E.) adicra* (Waagen)], *Docidoceras* (?) *transiens* (Bremer), and significantly, *Fontannesia* cf. *F. clarkei* (Crick) var. *whitehousei* Arkell. *Docidoceras longalvum limatum* is distinguished from *D. longalvum* s.s. only in the longer primaries more or less reaching up to the subsequent umbilical seam of the 'serpenticone' shell. The primaries of the New Guinea specimen do not, however, reach the length of *D. l. limatum* on the body chamber, while the secondaries are usually less convex on the European forms.

Docidoceras perfectum Buckman from England and '*Coeloceras*' *trapanicum* Renz from Sicily were included in *D. longalvum*, representing subspecies at the most, after restudy of the type material from San Vigilio (Westermann, 1964).

The other known species of *Docidoceras* s.s. are much more inflated and, usually, more involute. Of special interest is the resemblance in the projected ribs and presence of an umbolateral groove with the south Alaskan *Docidoceras* spp. which are presently being described under a new subgenus (Westermann, 1969b).

Measurements. —

	Dmm	H%	W%	U%	P	S
end phragm.	53	27	47	49	17	—
body ch.	65	31	46	50	19	55
aperture	93	24	34	54	c.22	45

(?) ***Docidoceras* (*Docidoceras*)** sp. indet.

Pl. 50, fig. 2

Material. — A single incomplete 1/2 whorl body chamber with poorly preserved remains of phragmocone, internal mold.

Discussion. — On the last whorl of the phragmocone, strong rectiradiate primaries bearing extended tubercles are visible. The body chamber fragment is medium evolute, the section being depressed and markedly ovate with the rounded lateral edge at approximately 2/5 whorl height. The primaries are prominent and somewhat bullae-like, dividing somewhat irregularly into three and sometimes four blunt moderately prosoradiate secondaries which are markedly convex on the venter.

This specimen resembles the afore-described *Docidoceras long-*

alvum (Vacek) from which it is distinguished only in the more inflated, somewhat ovate and more involute whorls. However, without preserved septum or suture, the slight possibility exists that this is a stephanoceratid.

Measurements.—

	Dmm	H%	W%	U%	P	S
body ch.	55	31	51	(c.40)	—	—
“	70	31	45	42	15	50

Family **STEPHANOCERATIDAE** Neumayr, 1875

Genus **STEPHANOCERAS** Waagen, 1869

Stephanoceras (*Stephanoceras*) aff. *S. humphriesianum*

(J. de C. Sowerby) 1825 ♀ Pl. 51, figs. 1 a-b; Text-fig. 7

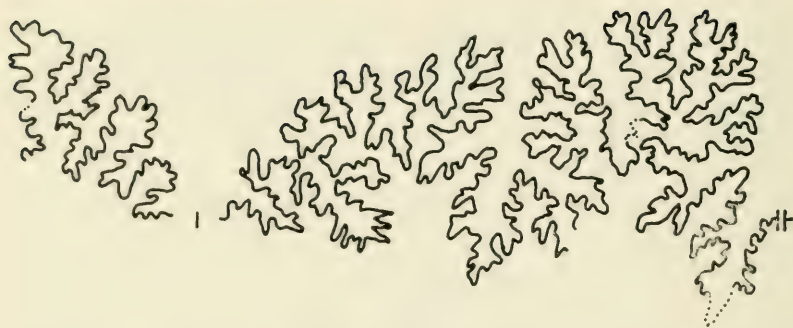
Material.—One fragmentary internal mold with parts of the three last whorls of phragmocone and the beginning of body chamber, one side damaged.

Description.—The ultimate and penultimate whorls of the phragmocone are weakly depressed subelliptical, slightly ovate in section with the maximal whorl width at about $2/5$ whorl height, with gently sloping inner flanks (umbilical slope) and somewhat flattened venter. The ultimate whorl is evolute, overlapping only about one-quarter of the preceding whorl while the penultimate whorl almost reaches the nodes of the antepenultimate whorl; thus, the inner whorls appear to have been less evolute. The egression of the umbilical seam seems to have continued with the body chamber, giving the shell a ‘planulate’ appearance.

The ornament of the antepenultimate whorl consists of sharp, rectiradiate primaries ending in tubercles. The primaries of the last two whorls are also sharp but somewhat rursiradiate and curved anteriorly. From the distinct round lateral tubercles arise more or less rectiradiate dense and fine secondaries in groups of three or, more rarely four, which cross straight over the venter. At the beginning of the body chamber, both primaries and secondaries become blunt.

The septal suture (Text-fig. 7) is complex; externally with large E/L saddle, slender and deep L of the same length as E, broad bifid L/U₂ saddle and strongly oblique U₂; internally with large I/U_n saddle, deep oblique U_n and much smaller oblique U_n/U₃ saddle.

Discussion.—The genus *Stephanoceras s.l.* is in a state of utter



Text-fig. 7.—Adult septal suture of *Stephanoceras* (*Stephanoceras*) aff. *S. humphriesianum* (J. de C. Sowerby), at approximately 10 cm diameter, from Kemaboe Valley (R.G.M. Leiden, st. 126191).

confusion and grossly 'split' at the genus-group and species levels (Westermann, 1964, p. 66 ff). Experience on several continents suggests that a small fraction (10-20 per cent) of the taxa would suffice. The 'planulate' *S. humphriesianum*, type species, almost certainly intergrades with the more inflated and involute and also more common 'plexus' of *S. umbilicum* and *S. mutabile*, F.A. Quenstedt spp., [= ? *S. brodiaei* (J. Sowerby)] all of which are usually associated; this group is characterized by moderately fast increasing, rounded subelliptical whorls with fine costae bearing tubercles. To this 'plexus' belongs also the northeastern Pacific *S. caamanoi* (McLearn) from the *S. humphriesianum* Zone of Queen Charlotte Islands; it is generally restricted to the *S. humphriesianum* Zone and derived from the 'serpenticone' but otherwise similar subgenus *S. (Skirroceras)* of the *O. sauzei* Zone. *Stemmatoceras* Mascke is difficult to separate and distinguished only by the more strongly depressed sublenticular whorls with well-defined lateral edge and more prominent primaries or bullae; however, there is intergradation of probably interrelated features, intraspecifically as well as morphogenetically, with *Stephanoceras* s.s. on the one hand and *Teloceras* Mascke on the other, the latter becoming distinct usually only if large and fully grown. Consequently, *Stemmatoceras* and *Teloceras* are best distinguished from *Stephanoceras* at the subgeneric level only. In the northeastern Pacific area, the *Stemmatoceras-Teloceras* complex of a single bed (Rock Creek Member) in the *S. humphriesianum* Zone of Alberta, for example, has been divided into 12 (macroconchiate) 'species' comprising an apparently

continuous sequence of shells with more or less depressed sublen-ticular whorls bearing coarse primaries of different prominence; the first named form is *S. charlottensis* (Whiteaves) which re-sembles *S. triptolemus* (Morris and Lycett) with the inner whorls of *S. (Stemmatoceras)* and the outer whorls of *Stephanoceras s.s.* Both *S. (Stemmatoceras)* and *S. (Teloceras)* seem to occur in the *O. sauzei* and *S. humphriesianum* Zones, although the latter is rare in the *O. sauzei* Zone (if not there misidentified). In Europe *S. (Teloceras)* seems to range into the *S. subfurcatum* Zone, as does *S. (Stemmatoceras)* in the Western Interior of the United States and southeastern Alaska (Imlay, 1962, 1967); however, some of the Western Interior forms could be *Cadomites*. The micro-conchs of *Stephanoceras s.l.* which have usually been classified under *Normannites s.l.*, are still difficult to match on the specific and even on the subgeneric levels and their discussion is not again at-tempted here (Westermann, 1964). However, there can be no serious doubt about their 'generic' correspondence.

The New Guinea specimen resembles closely *S. humphriesi-anum* (J. de C. Sowerby) and especially '*S. caamanoi*' McLearn which is here regarded as a junior synonym; the occurrence of somewhat curved primaries as in our single specimen may be some-what more frequent in North American *Stephanoceras* than in the European representatives, but this is a variable and therefore prob-ably not diagnostic feature. Our specimen differs from 'typical' *S. humphriesianum* in the broader and slightly less evolute whorls, thus being intermediate to *S. mutabile* (F.A. Quenstedt).

Measurements. —

	Dmm	H%	W%	U%	P	S
end phragm.	c.100	c.34	c.44	c.35	c.24	c.60

? Subgenus **S. (STEMMATOCERAS)** Mascke, 1907

(?) **Stephanoceras (Stemmatoceras?) etheridgei** (Gerth) 1927, ♀

?1890. *Stephanoceras* allied to *S. Blagdeni* J. Sowerby, Etheridge (New Guinea), Rec. Geol. Survey New South Wales, vol. 1, p. 175, pl. 29, fig. 2.

?1927. *Stemmatoceras etheridgei*, Gerth (New Guinea), Leidsche Geol. Meded., vol. 2, p. 226, pl. 36, fig. 1 only [here refigured, Text-fig. 8].

?1962. *Stemmatoceras* aff. *indicum* (Kruizinga), Donovan in Visser and Her-mes (W. New Guinea), Verh. Ned. Geol. Mijnbouw, genoot., geol. Ser. XX, p. 55, encl. 17, figs. 10 a-c.

?1962. *Stemmatoceras brodiaei* (J. Sowerby), *ibid.* p. 55, encl. 17, figs. 16 a,b.

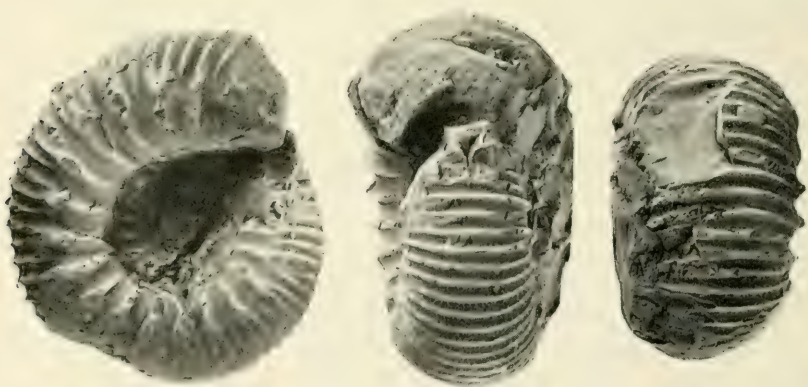
Material. — One incomplete and partly damaged internal mold,

inner whorls with shell remains crushed on one side, ultimate whorl worn.

Description.—The inner whorls (<23 mm D) are medium evolute and almost planulate, with moderately depressed, somewhat subelliptical section. The penultimate and ultimate whorls, the latter probably belonging to the body chamber, become rapidly more depressed and sublenticular in section with the lateral edge at mid-flank. The inner flanks slope gently to the umbilical seam and the ventral area is evenly rounded.

The ornament is strong throughout consisting of prominent straight and only slightly prosoradiate primaries which arise rapidly from the umbilical seam but withdraw from it on the ultimate whorl; they bear round tubercles at least on the better preserved inner whorls where they are partly overgrown by the ultimate whorl. The secondaries of the inner whorls are concealed; on the ultimate whorl, they arise in twos or, more rarely, threes from the primaries, curving forward but bending backward before reaching the venter which they cross straight at full strength, thus suggesting weak tabulation. Septum and suture are not preserved.

Comparison.—The specimen resembles the holotype of *S. etheridgei* (Gerth) (♀) from the Vogelkopf Peninsula (?) which is here refigured (Text-figs. 8 a-c). The inner whorls of the holotype, although poorly preserved, can be seen to bear similarly prominent primaries with tubercles; they are also more planulate than the end of the conch as is evident from the relatively narrow

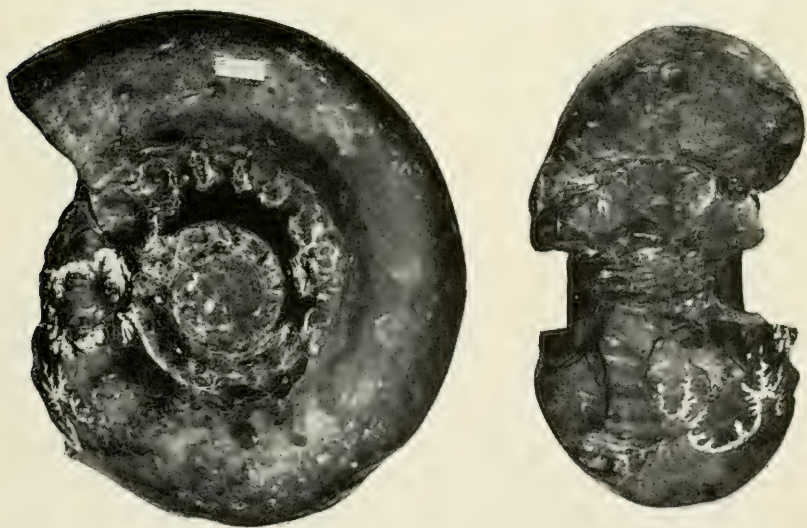


Text-fig. 2.—Holotype of *Stephanoceras* (*Stemmatoceras*) *etheridgei* (Gerth) ♀, from the Vogelkop Peninsula (loc. 1 ?). (R.G.M. Leiden, st. 1272) $\times 1$.

beginning of the ultimate whorl. However, the holotype becomes less inflated than our specimen; the secondaries become proso-radiate only on the ultimate one-half whorl and ventral straightening is only faintly suggested. However, this may be partly due to the somewhat smaller size.

The ventral costal features of our specimen are unknown from any other *Stephanoceras s.l.* and may be characteristic of fully grown *S. etheridgei*, together with the remarkable change of whorl section. The secondaries are also stronger than in most species of *S. (Stemmatoceras)* under which name it is kept with modest confidence. Nevertheless, there is some resemblance to the new genus *Irianites* in the change of whorl section and the unusual secondaries, so that this specimen was originally classified with the much more abundant form.

The West Irian specimens identified by Donovan (*in* Visser and Hermes, 1962) as *Stephanoceras (Teloceras)* aff. *S. indicum* (Kruizinga) and *S. brodiaei* (J. Sowerby), which were reinvestigated and partly further developed from the matrix, are probably identical with this species. "*Coeloceras*" *indicum* Kruizinga [*? nomen dubium*] (1926), the poorly preserved holotype of which



Text-fig. 9. — Holotype of "*Coeloceras Indicum*" Kruizinga [= *Stephanoceras (Teloceras) indicum* Kruizinga ♀], from the Sula Islands. (Geol. Inst., Univ. Amsterdam, F. 9884) x6.5.

is here refigured (Text-fig. 9), belongs also to *Stephanoceras s.l.*

Measurements. —

	Dmm	H%	W%	U%	P (½ wh.)	S
phragm.	26	29	40	c.35	11	—
? body ch.	42	31	50	41	12	—
"	60	36	59	38	c.13	c.30
<i>S. etheridgei</i> , holotype						
? body ch.	c.35	c.36	c.50	c.40	(c.10)	—
"	52	—	55	—	10.5	31
"	55	34	54	36.5	11	32

Stephanoceras (Stemmatoceras?) etheridgei (Gerth) ?, ♂ ?

Pl. 51, figs. 2 a,b

Material. — One almost complete internal mold with test remains, aperture missing.

Discussion. — The specimen measures only 39 mm diameter at the end of the three-quarter whorls incomplete body chamber. However, in the absence of preserved septal sutures and marked modification of the body chamber, it is not possible to decide if this is a fully grown microconch (or male) shell or an immature macroconch (or female).

This small shell closely resembles the inner whorls, comparable in size, of the macroconchiate *S. (Stemmatoceras) etheridgei*, described above (cf. Text-fig. 8). The almost planulate, not strongly depressed whorls become somewhat sublenticular and bear widely spaced prominent primary and secondary costae with lateral tubercles.

This example illustrates the need for a classification (and name) which reflects the strongly apparent dimorphic relationship of the macroconchs hitherto solely included in *Stephanoceras s.l.* and the microconchs previously all included in *Normannites s.l.* Westermann (1964) suggested earlier placing these complementary 'monosexual parataxa' as subgenera in the same genus; in this instance, the subgenus would be *Stephanoceras (Itinsaites)*. However, the same author now prefers to draw the dimorphic complementary genera/subgenera into synonymy.

This microconch is closely affiliated with '*Kanastephanus*' *crickmayi* and '*K.*' *mackenzii*, McLearn spp., from the *S. humphriesianum* Zone of Alberta which seem to correspond to the macroconchiate *Stephanoceras skidegatense* (Whiteaves) *s.l.*

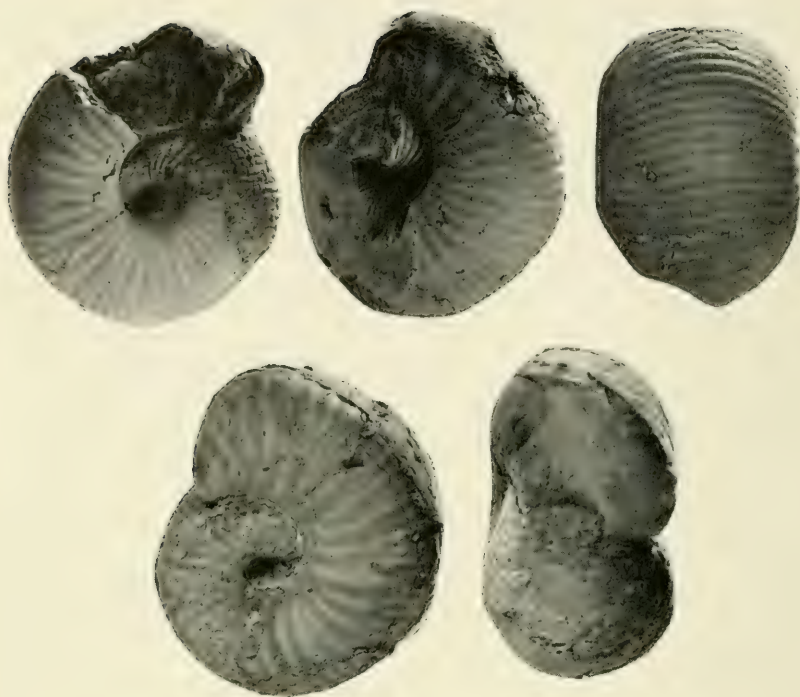
Measurements. —

		Dmm	H%	W%	U%	P	S
body	ch.	39	31	51	43	9	25
"		c.28	c.33	51	41	c.9	—

(?) Family **TULITIDAE** Buckman, 1921

Approximately one-seventh of the Kemaboe Valley collection (c.38 specimens) consists of previously unknown 'sphaerocones' with dense, mostly prosoradiate ribbing and 'raised' septal suture with the 'internal lateral lobe' consisting of the primary lobe U_1 (Text-fig. 12). Three size groups are present: five specimens are large with modified outer whorl; approximately 23 specimens are of medium-small size bearing a constricted but incompletely known aperture; nine or 10 specimens are small with constricted and lappet-bearing apertures. While the former are certainly macroconchs (females) and the latter microconchs (males), the large intermediate size group cannot be assigned without doubt to either dimorph although the apertural constriction and unmodified body chamber suggest that they were microconchs. Only a single species is named, based on the best represented form. Since Jurassic 'sphaerocones' with U_1 as 'internal lateral lobe,' *i.e.* the eubullate septum, are known only in the Tullitidae (Westermann, 1956a; Schindewolf, 1965), these forms are somewhat tentatively placed in this family. All available septal sutures differ in the more or less slender U_2 ("second lateral lobe") which is broad and bifid or multifid in apparently all known Tullitidae; most specimens differ also in the denser and more inclined costae as well as in the less strongly ellipticone and contracted body chamber. Other Mesozoic sphaerocones with a modified eubullate septum are the basal Cretaceous Olcostephanidae (Schindewolf, 1966, p. 387); these are, however, distinguished in whorl section, ornament, the broad U_2 lobe and perhaps, the different shape of U_1 .

On the other hand, there is resemblance particularly in costation and septal suture to the Eucycloceratinae Spath which are also of uncertain taxonomic position but appear to be affiliated more closely with the sphaerocones described here than with Macrocephalitidae proper.



Text-figs. 10-11. — Comparison (above) "*Sphacroceras* cf. *bullatum* d'Orb." (Gerth, 1927, p. 226) [= *Bullatimorphites* (*Treptoceras*) aff. *B. uhligi* (Popovici-Hatzeg) from supposed Callovian of the Wairori River (loc. 1), with (below) a topotype of *B. (T.) "suevicum* (J. Roemer)" [= *B. uhligi*] from the *O. aspidoides* Zone, Upper Bathonian, of Hildesheim, Germany (Niedersächs. Landsamt Bodenforschung). x1. Original Coll. B.F. B./N.L. f B han-nover 6537.

?Genus **BULLATIMORPHITES** Buckman, 1921

Bullatimorphites ?, n. sp. ♀

Pl. 52, figs. 1-3

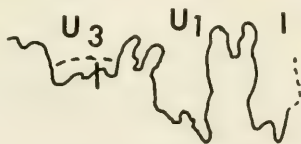
Material. — Two phragmocones with incomplete body chambers; one phragmocone; two fragments of large body chambers of which one has part of the penultimate whorl; all rather well-preserved internal molds with minor test remains.

Description. — The inner whorls (<30-35 mm D) are moderately involute with slightly depressed rounded whorls; the intermediate whorls are involute with compressed cadicone section in

The costation consists of curved, dense, and sharp primaries which divide just below mid-flank into two, more rarely three very dense, prosoradiate and continuous secondaries. The outer whorls (>45-60 mm D) become gradually much more evolute, depressed and typically cadicone with vertical umbilical wall bounded by a weakly rounded margin marking the broadest whorl width. The primaries retract from the umbilical wall and become rapidly more widely spaced swelling into lower-lateral bullae while the secondaries remain dense, being about five times as abundant as the primaries. The full diameter is estimated at 100-120 mm. It appears probable that the large body chamber fragments belonged to the same species as the smaller incomplete specimens.

The juvenile septal suture at a few millimeters diameter (R.G.M. Leiden, st. 126194) has an oblique 'internal lateral lobe' separating the two saddles and a shallow (U_3) lobe at the umbilical seam, in all closely resembling the early suture of *B.?* (*Treptoceras?*), n. sp. A (Text-fig. 12). The 'internal lateral lobe' is, therefore, probably homologous with the primary 1st umbilical lobe, U_1 . The mature external part of the suture (st. 126195) is moderately complex, consisting of subequal E/L and L/U saddles divided by a narrow trifold L which is approximately as deep as E; U_2 resembles L except for the somewhat smaller size; the other umbilical elements are small and straight, the saddle line rising somewhat toward the umbilical seam.

Discussion. — The inner phragmocone whorls resemble certain *Bullatimorphites* Buckman, especially *B. (?) sof anum* (Boehm, 1912, pl. 35, figs. 2a-b) from the Bathonian-Callovian of the Sula Islands¹) which also has dense, long, and curved primaries on the



Text-fig. 12. — Juvenile incomplete (internal) septal suture of *Bullatimorphites?* (*Treptoceras*) n.sp. A ♂, at 2.5 mm diameter, from Kemaboe Valley (R.G.M. Leiden, st. 126204).

¹ This species is probably also present in the *M. macrocephalus* Zone of Chos-Malal in the Argentina Andes (Westermann, 1967, fig. 2).

phragmocone but is distinguished by coarser secondaries, more evolute and depressed whorls, and the multifid U_2 lobe. The intermediate whorls, at least of two specimens, are more compressed than in any known (macroconchiate) tulitid. The body whorl with its gradual uncoiling, with steep umbilical slope and with bullae-like primaries is, however, more like that of *Tulites* (*Rugiferites*) Buckman, slightly resembling *T. (R.) (?) godohensis* (Boehm, 1912, pl. 35, figs. 1a,b), also from the Sula Islands assemblages; *T. (?) godohensis* differs in the more evolute and much more coarsely ornate phragmocone and the broad bifid U_2 lobe.

The late Middle Bajocian *Chondroceras* (*Defonticeras*) McLearn also shows some superficial resemblance but is distinguished by more involute inner whorls, rounded outer whorls, smaller size, and particularly by the abullate septum with U_n . *C. (?) (Praetulites)* Westermann (1956) which is probably of late Bajocian (+? Bathonian) age (Sturani, 1964a), has a prominent lateral edge and short primaries.

The compressed inner whorls, the variocostate (strengthening) primaries, and the somewhat rising umbilical lobes with slender U_2 are all reminiscent of the Eucycloceratinae; however the umbilical elements of the suture are by far not so strongly raised as in that group (at least not in the mature shell) and the outer whorls differ in section.

? Subgenus **TREPTOCERAS** Enay, 1959

Treptoceras was proposed by Enay (1959) for small Tulititidae combining the features of the inner whorls of *Bullatimorphites* with those of the aperture of *Schwandorfia* but bearing a more oblique apertural constriction.

Such a combination was first shown in the figure of *A. microstoma* d'Orbigny (1846, pl. 143, figs. 3,4) which Arkell (1954, p. 110) considered a synthetogram since none of the material in D'Orbigny's collection possessed lappets. Lappets do occur, however, in '*A. microstoma*' Quenstedt (1886, pl. 78, fig. 4) which Arkell (*loc. cit.*), therefore, considered to be, probably, a new genus. New material from northwestern Germany (Westermann, 1958, p. 66) and eastern France (Enay, 1959) confirmed the presence of lappets.

Because of the probable dimorphic relationship with the much larger *Bullatimorphites*, but in the absence of known specific correspondences, *Treptoceras* is preliminarily classified as a sub-genus of that genus in accordance with the convention regarding probable sexual dimorphs (Callomon, 1963; Westermann, 1964). More than one-half of the sphaerocones from the Kembelangan Formation cannot be definitely identified as to sex, *i.e.* macroconch or microconch but can be classified as *Bullatimorphites* if this includes the microconchiate *B. (Treptoceras)*.

Most specimens here described from West Irian differ from known species of *B. (Treptoceras)* in the more regularly coiled and not markedly 'contracted' body chamber, in the denser, more strongly prosoradiate ribs, and probably, in the slender U_2 ("second lateral") lobe.

B. (Treptoceras) is known from the Middle Bathonian to the Lower Callovian. Important occurrences are in the Middle Bathonian of Crussol (Enay, 1959); the Upper Bathonian of the Paris Basin (de Grossouvre, 1888) and of the Weser Mountains near Hildesheim in Lower Saxony (J. Roemer, 1911; Westermann, 1956b); the lower Callovian of the Paris Basin (Corroy, 1932), of Kutch in India (Spath, 1931), and, probably, of the southern Andes (unpublished).

While this paper was in press, the senior author was informed about new and unpublished findings of later occurrences of microconchiate *Bullatimorphites*. Dr. A. Zeiss of the University of Erlangen-Nürnberg and Dr. W. Hahn of the Geological Survey Baden-Württemberg recovered single specimens from the Middle Callovian and Upper Callovian *P. athleta* Zone of the Swabian Jura. Unfortunately, the specimens or photographs were not available.

Bullatimorphites* (?) (*Treptoceras* ?) sp. aff. *B. microstoma

(d'Orbigny) 1846 ♂

Pl. 53, figs. 2 a-c

Material. — One complete internal mold with partly preserved aperture and exposed penultimate whorl.

Description. — The small shell (48 mm D) is relatively evolute (U of phragmocone = 23% of D) and weakly inflated for the genus; the body chamber is only weakly elliptically coiled and not markedly 'contracted.' The last phragmocone whorl is moderately depressed ovate, the vertical umbilical slope gently rounding into

the flanks with the maximal whorl width at about one-third whorl height, and with evenly rounded ventral area. The dense strongly prosoradiate primaries divide just below mid-flank into two or three dense, sharp, somewhat back-curved secondaries which cross almost straight over the venter:

The body chamber, just over three-quarters of a whorl in length, unwinds somewhat more strongly at the beginning and curves at the end, resulting in weakly 'elliptical' coiling. Whorl height ceases to grow and whorl width growth decreases so that the whorl section becomes more depressed ($H/W\ 0.71 > 0.62 > 0.59$). The primaries remain dense and become prosoradiate, high and sharp on the last one-half of the body chamber, now reaching well beyond mid-flank and bifurcating regularly into the almost straight secondaries. Immediately before the aperture, the whorl contracts slightly and a terminal constriction truncates the ribs obliquely. From the expanding flange extend ventro-lateral lappets (one preserved). Although incompletely preserved, the lappet was probably small and simple.

The mature external septal suture has subequal E/L and L/U ("1st and 2nd lateral") saddles divided by a narrow L lobe, and a slender and trifid U₂. The smaller umbilical elements are not markedly suspensive and are straight to slightly oblique.

Comparison. — The specimen differs from all previously described species of *B. (Treptoceras)* in the body chamber which is more regularly coiled, not 'contracted' (except for the aperture), and becomes more depressed rather than rounded, as well as in the slender U₂ lobe. It is closest to the middle to late Bathonian *B. (T.) microstoma* (d'Orbigny) (Enay, private comm.), a species exhibiting appreciable variability (De Grossouvre, 1888). *B. (T.) laurenti* Enay and *B. (T.) crimaciensis* Enay are more compressed with prominent ventral flares at the aperture. The other known species of the subgenus are more involute. *B. (B.?) sofanum* (Boehm, 1912, p. 150, pl. 35, figs. 2 a,b) from the Sula Islands appears to have similar inner whorls but is much larger and varicostate, the body chamber bearing widely spaced ribs.

Measurements. —

	Dmm	H%	W%	U%
end body ch.	44	33	56	30
body ch.	38	39.5	63	28
end phrag.	26.5	51	72	23

Bullatimorphites (Treptoceras) sp. aff. *B. uhligi*

(Popovici-Hatzeg) 1905 ♂

Pl. 53, figs. 1 a,b, 3 a,b

Material. — One damaged internal mold with incomplete aperture; one incomplete specimen with end of phragmocone, one-half whorl of body chamber and mold of penultimate whorl; both from the Kemaboe Valley. One damaged but otherwise complete internal mold from the 'Callovian' of the Wairori River (original of Gerth, 1927, p. 226: "*Sphaeroceras* cf. *bullatum* d'Orb."; R.G.M. Leiden, st. 12118).

Description. — The phragmocone is globular with strongly depressed ovate and involute whorls ($U = 15\%$ of D), and dense prosoradiate sharp primaries which bifurcate or trifurcate at about mid-flank into dense straight secondaries. The complete body chamber, a full whorl in length, has typically 'elliptical' coiling with marked geniculation at the beginning and at half-length, and is laterally contracted resulting in a much less depressed whorl section. The umbilical slope becomes shallow and the ventral area weakly convex. Primaries and secondaries, now in pairs, become somewhat more widely spaced but blunter. The aberrant ventral costae feature on the body chamber of the smaller specimen is obviously pathological, probably a result of pallial injury. The aperture is marked by an oblique constriction followed by a lateral flange very probably bearing the base of ventro-lateral lappets. The complex last septal suture has broad subequal E/L and L/U ("1st and 2nd lateral") saddles and slender L and U_2 lobes; the following smaller umbilical elements are straight and somewhat raised. The specimen from the Callovian of Wairori River (Text-fig. 1, loc. 1) described by Gerth (*loc. cit.*) is now illustrated (Text-fig. 10); it closely resembles the two Kemaboe Valley specimens described above.

Comparison. — The specimen closely resembles the Upper Bathonian and (?) lower Callovian *B. (T.) uhligi* (Popovici-Hatzeg); the holotype from Romania was refigured by Arkell (1954, text-fig. 36, right). This species includes '*Sphaeroceras Suevicum*' J. Roemer (1911) (text-fig. 12), which is common in the *O. aspidoides* Zone (?) and Lower Callovian) of the Hildesheim area in northwestern Germany (Westermann, 1958, pp. 66,67; probably also '*B. microstoma microstoma*' with lappet) and is

closely allied to Lower Callovian forms described from Franconia (Kuhn, 1939, pl. 3, fig. 31; pl. 7, figs. 2,9). *B. uhligi* is distinguished from our specimen by the smaller size and the blunter more widely spaced ribs at least on the body chamber. *B. (B.?) sofanum* (Boehm) is larger, more evolute, and more coarsely ribbed, especially on the venter. According to Enay (priv. comm.), *B. microstoma* (d'Orbigny) is distinguished from *B. uhligi* mainly in the somewhat wider umbilicus; however, according to Westermann's own brief study of D'Orbigny's original specimen in the Muséum National d'Histoire Naturelle, Paris, this supposed differential feature needs closer study.

Bullatimorphites (?) (Treptoceras ?) costidensus

Westermann and Getty, n. sp. (♂ ?)

Pl. 54, figs. 1-4

Holotype. — Pl. 54, fig. 3 a-e (R.G.M. Leiden, st. 126203); almost complete body chamber (5/4 whorls) and part of phragmocone. From pebbles of the Kemaboe Valley, Kembelangan Formation, West Irian.

Diagnosis. — Almost medium-sized (? microconchiate) *Bullatimorphites*, involute, body chamber without strong elliptical coiling or contraction; costation extremely dense, sharp and prosoradiate throughout, with long primaries.

Material. — Fifteen body chambers, more or less complete but usually somewhat distorted, with some remnants or molds of phragmocones, several apertural constrictions, but no complete aperture; also several smaller fragments. All from pebbles of the Kemaboe Valley.

Description. — At least the intermediate and outer phragmocone whorls are tightly coiled ($U = 18\%$ of D) and depressed ovate in section, with the vertical umbilical wall rounding into the flanks. The phragmocone is, therefore, typically sphaerocone with a 'thickness' (W/D) of 65 to 85%. The body chamber, about a full whorl in length, unwinds gradually, the coiling becoming only weakly 'elliptical,' and becomes more compressed by cessation of width growth; but there is only weak or no 'contraction.' The umbilical wall becomes more shallow as the seam egresses. The final diameter is between 50 mm and 60 mm, except for a single specimen which shows markings of segmental growth and is 70

mm large. The outer whorls, including the body chamber, are densely ribbed. The thin sharp primaries arise more or less rectiradiate on the umbilical wall but soon swing strongly forward. They divide at about mid-flank into two or three dense secondaries which on the flanks are also strongly adorally inclined. The secondaries tend to bend backward besides the venter which they cross more or less weakly convex. However, the connection between primaries and secondaries is weak and the secondaries are occasionally intercalated.

The aperture is marked by a strongly oblique constriction of the internal mold truncating the costae. A ventral flare is missing or weak. Although no peristome is complete, small remnants seem to indicate that ventro-lateral lappets were present.

The septal suture (R.G.M. Leiden, st. 126232) is complex, with subequal E/L and L/U ("1st and 2d lateral") saddles and slender, deep-rooted trifid to multifid L and U₂ lobes. The exposed last septal surface of the holotype shows also the raised smaller umbilical elements near the seam, the subequal two "internal saddles" and the bullate (eubullate?) septal structure.

Although it is not certain that the aperture had lappets, this form is probably a large microconch (or male).

Comparison.—The phragmocone resembles the Upper Bathonian and (?) Lower Callovian *B. (T.) uhligi* (Popovici-Hatzeg) discussed above, except for the denser more strongly inclined ribs and the more slender U₂. *B. (?) sofanum* (Boehm) differs in being more loosely coiled, in the stronger secondaries and the larger, modified body chamber; but it has a similar U₂ lobe. The body chamber of this New Guinea species is more regularly coiled without marked contraction, and more densely ribbed with strongly inclined primaries and secondaries than in any described *Bullatimorphites*. The mutual resemblance of the different New Guinea forms here described and their similarity to the Eucycloceratinae probably reflect some phylogenetic relationship.

It is possible that this form is the microconch (male) complement to the clearly macroconchiolate (female) *Bullatimorphites?* sp. n. ♀ described above although the inner whorls of the latter are usually more compressed (cf. Pls. 52,54).

Measurements. —

	Dmm	H%	W%	U%
Holotype: body ch.	54	44.5	52	24
" "	39	47	72	18
" "	31	48	71	—
R.G.M. Leiden, st. 126202				
body ch.	60	40	52	25
" "	46	44	63	20.5
" "	35	46.5	65	—

Bullatimorphites ? (*Treptoceras* ?), n. sp. A ♂

Pl. 55, figs. 1-5; Text-fig. 12

Material. — Three almost complete specimens with partly preserved inner whorls, one of them with lappets; four larger fragments, one of them associated in same concretion with external mold of *Irianites* cf. *I. moermanni* (Kruizinga); one incomplete body chamber with aperture. All internal molds with minor test remains.

Description. — The small shell is of medium thickness and coiling, almost planulate if complete. The phragmocone whorls are loosely coiled for the genus, with open stepped umbilicus ($U \sim 25\%$ of D). The whorl section is only slightly depressed, ovate almost subcircular, the flanks rounding gently into the steep umbilical slope and into the strongly arched venter. The 'thickness' (W/D) at the end of the small phragmocone (25-32 mm D) is only about 55-60%. The body chamber, $3/4$ to $4/5$ whorls in length, unwinds gradually to become moderately evolute ($U \sim 30\%$ of D) and more compressed; the width growth rate is reduced while height growth rate remains approximately constant except for the reduction at the peristome. The body chamber shows neither marked "elliptical" coiling nor contraction. The adult diameter is approximately 45-55 mm.

The costation is dense throughout. At least the last two whorls, including the body chamber, bear 25-30 long and sharp primaries per halfwhorl, which arise almost perpendicularly near the umbilical seam and bend strongly forward on the flanks, becoming markedly prosoradiate. On the phragmocone, the primaries divide about mid-flank into two, more rarely three extremely dense secondaries tending to bend back toward the radius beside the venter which they cross more or less straight. On the body cham-

ber, the primaries extend beyond mid-flank to about $3/5 - 2/3$ whorl height and the furcation may become somewhat irregular, with some intercalatories. One specimen (Pl. 55, fig. 3) differs somewhat in the larger numbers of secondaries which vary in length on the body chamber.

The aperture is marked by an oblique constriction truncating the costae; but there is no conspicuous ventral flare. This is followed adorally by a narrow collar and broad, probably simple ventro-lateral lappets. Their shape is, however, unknown due to incomplete preservation.

The septum is eubullate with two complete (paired) saddle axes, and shallow smaller umbilical elements around the seam. The mature septal suture has accordingly, subequal external and internal "1st" and "2nd lateral saddles," and straight (non-suspensive) sutural elements. U_2 is slender. The early juvenile suture (Text-fig. 12; 2.5 mm D) as developed from the most complete specimen, has a shallow U_3 lobe which is only one-third as deep as I and a somewhat oblique, asymmetrically bifid (modified trifid) 'internal lateral lobe.' This is significantly like early sutures figured from *Bullatimorphites* (Westermann, 1956a, text-figs. 4,5; Schindewolf, 1965, text-fig. 263) and good evidence for the normal ("orthochronic") development of the umbilical lobes; the morphological internal lateral lobe is, therefore, U_1 (not U_n as in otoitids, sphaeroceratids, macrocephalitids, kosmoceratids, and cardioceratids).

Comparison.—This new unnamed species resembles most closely *B.?* (*T.?*) *costidensus*, n. sp. from which it is distinguished by the smaller size and the thinner, more evolute whorls. Of previously described *B. (Treptoceras)* species, this New Guinea form is best compared with the Swabian *B. microstoma* (d'Orbigny) of Quenstedt (1886, pl. 78, figs. 3,4) (Enay, private comm.) which is, however, distinguished by the more involute phragmocone, the rectiradiate costae, the presence of a ventral flare, and the elliptical coiling of the body chamber. Specimens similar to those of Quenstedt were figured from the Lower Callovian of Franconia (Kuhn, 1939, pl. 6, fig. 3), and the Upper Bathonian of eastern France (Enay, 1959, pl. 7b, fig. 7).

As in at least most of the other questionable Tulitidae here

described, there is also an affinity to the inner whorls of Eucycloceratinae: *Subkossmatia*, *Eucycloceras* and ? *Idiocycloceras* [? also the Oxfordian or Tithonian *Grayiceras* Spath], which they also resemble in the slender U₂; however, the umbilical elements of the suture are not raised but follow a radial saddle line. In contrast, resemblances to the Middle Bajocian *Labyrinthoceras* or *Chondroceras* or even *Cadomites* (*Polyplectites*) (Callomon, private comm.) are considered as mere homeomorphs, particularly because of the significant differences in the septum and its suture.

Of the previously published Indonesian material there is some resemblance to the widely umbilicate and densely ribbed '*Macrocephalites keeuwensis* γ' Boehm (1913, p. 14, pl. 4, figs. 2a, b only) from West Irian, which could be an *Idiocycloceras*.

Age. — The stratigraphic position of this species is at least in part the same as that of *Irianites* cf. *I. moermanni* (Kruizinga) with which it was found associated (Pl. 55, fig. 4). Because of the association of *I. moermanni* with *Bositra buchi* (Roemer) (Pl. 58, fig. 1c) the age of both forms is post-Pliensbachian and pre-Kimmeridgian.

Measurements. —

	Dmm	H%	W%	U%
R.G.M. Leiden, st. 126204				
aperture	47	36	48	31
body ch.	37	45	53	26
"	31	47	56.5	24
st. 126205				
aperture	47.5	36	48.5	29.5
body ch.	38	42	50	24
"	c.27	c.44	(c.56)	c.24

? Family **MACROCEPHALITIDAE** Buckman, 1912

[or ? **TULITIDAE** Buckman, 1921, or ? **MAYAITIDAE**, Spath, 1928]

Subfamily **EUCYCLOCERATINAE** Spath, 1928

The genera *Eucycloceras* Spath, 1928, *Subkossmatia* Spath, 1924, *Idiocycloceras* Spath, 1928, and ? *Nothocephalites* Spath, 1928, are retained separately from the macrocephalitids (proper) at the subfamily level [originally as family Eucycloceratidae]; this is based on their clear distinction in costation, coiling, and septal

suture. They were all included in the Macrocephalitidae in the 'Treatise' (Arkell, *et al.*, 1957, p. L 294). At least in the studied (?) *Eucycloceras*, the early juvenile septal suture has strongly raised umbilical elements, indicating that the septum is eubullate, *i.e.*, the "internal lateral lobe" is U_1 as in the Tutilitidae and not U_n as in all other Middle Jurassic sphaerocones including the macrocephalitids (Westermann, 1956a, p. 258; Schindewolf, 1965, Abb. 248, 262, p. 179). The suture differs from Tutilitidae (and Bajocian sphaerocones) in the slender U_2 but resembles the *Bullatimorphites* ? n. spp. here described from the Kemaboe Valley 'pebble assemblage.' A similar sutural pattern may possibly also be present in the Upper Jurassic mayaitids although their juvenile stages are still unknown and there is exceptionally strong variation in the adults according to the figures of Spath (1928). It is tentatively suggested elsewhere (Westermann, 1970) to classify both the mayaitids and the eucycloceratids either as subfamilies of the Macrocephalitidae or, alternatively, to place them in a single separate family.

Genus **EUCYCLOCERAS** Spath, 1924

- (?) ***Eucycloceras intermedium*** Spath, 1928 (♂ ?) Pl. 56, figs. 2 a,b
 1912. *Macrocephalites keeuwensis*, sp. nov. β , Boehm (Sula Is.), Palaeontographica, Suppl. 4, pl. 38, fig. 3 a,b only.
 1928. *Eucycloceras intermedium*, nom. nov., Spath (Cutch), Paleont. Indica, N. S., vol. 9, mem. 2, p. 210, [for preceding].

Material.—Single fragment of one-half whorl of incomplete body chamber and remnant of penultimate whorl, internal mold.

Description.—The body chamber fragment (50 mm D) is moderately involute and strongly compressed with flat sides, vertical umbilical wall and narrow, slightly tabulate venter. The ribs are sharp, moderately dense and slightly falcoid. The curved prosoradiate primaries bifurcate or trifurcate at or just below mid-flank; the secondaries are rectiradiate but on the shoulder markedly projected and prominently arched over the venter. The septal suture is moderately complex with raised umbilical elements on ultimate and penultimate whorls (suggesting that the septum is eubullate).

Discussion.—This specimen closely resembles the holotype from the Sula Islands, but the specimens figured from northwestern New Guinea by Boehm (1913, pl. 3, fig. 3, ? 4; pl. 4, fig. 4, ? 5) under

the same original name of "*Macrocephalites keeuwensis* β " are probably more involute and more densely ribbed; these forms seem to be intermediate to *Subkossmatia* which they resemble in the coiling and ribbing, while they appear to have the venter of *Eucycloceras*.

? *Eucycloceras* sp. indet., δ ?

Pl. 56, figs. 1 a,b

Material. — A single small, almost complete specimen, with approximately one-half whorl of body chamber.

Description. — The specimen, which may be either a juvenile stage or a microconch, resembles closely the apparently complete microconch figured by Boehm (1913, pl. 4, figs. 3 a,b) from north-western New Guinea under "*Macrocephalites keeuwensis* γ var. *bifurcata*." The nucleus (5-10 mm D) has medium evolute whorls with depressed oval section and ventrally arched secondaries. The body chamber (20-33 mm D) becomes less depressed, only slightly broader than high; somewhat prosoradiate primaries of medium strength and spacing bifurcate at almost mid-flank into rectiradiate secondaries which cross over the venter with hardly perceptible arch. The septal suture has strongly raised umbilical elements as early as at 5 mm diameter, strongly indicating that the septum is eubullate.

Genus **SUBKOSSMATIA** Spath, 1924

The distinction of *Subkossmatia* from *Eucycloceras* appears to be poorly defined, due to the presence of intermediate forms so that separation at the subgeneric level is suggested here, although separation at the generic level was retained in the 'Treatise.'

Subkossmatia obscura Spath, 1928, **boehmi**

Westermann and Getty, n. subsp.

Pl. 56, figs. 3,4

Holotype. — *Macrocephalites keeuwensis* β - γ Boehm, 1913, p. 16, text-fig. 9 and pl. 5, fig. 2 [*non* Boehm, 1912], from Mamâpiri, N.W. New Guinea.

The use of the suffices α β γ δ and their combinations by Boehm (1912, 1913) to distinguish varieties of his comprehensive species *Macrocephalites keeuwensis* does not constitute the establishment of a new name, because they directly contravene Article

11g of the International Code of Zoological Nomenclature (1964). They are, therefore, without nomenclatural status and are not available. When Spath (1928, p. 212) emended Boehm's name to '*Macrocephalites keeuwensis beta-gamma*,' it is clear that he did not intend to propose a new name, because he still attributed its authorship to Boehm. This action of Spath's could be regarded as an unjustified emendation. It certainly cannot be regarded as the establishment of the new name '*Subkossmatia beta-gamma*,' as Arkell (1956, p. 448) erroneously stated.

Because the species figured by Boehm (1913, pl. 5, fig. 2) is different from the true *Macrocephalites* ('*Dolikephalites*') *keeuwensis* (Boehm), it is renamed here *Subkossmatia obscura* Spath *boehmi*, n. subsp.

Diagnosis. — A subspecies of *S. obscura* with broad almost quadrate whorls, body chamber with short primaries and dense secondaries.

Material. — One body chamber complete except for ventral part of aperture, with incomplete penultimate whorl; one incomplete body chamber with fragment of penultimate whorl; both internal molds with test remains, from the Kemaboe Valley.

Description. — Both specimens resemble closely the holotype from Mamâpiri. The moderately involute last phragmocone whorl has extremely dense, sharp, strongly prosoradiate primaries which become much more coarse, widely spaced, and shorter on the body chamber. The whorl section of the body chamber and penultimate whorl is rounded trapezoidal, almost subquadrate, with vertical umbilical slope and flat slightly converging flanks which round into the broad only moderately convex and very slightly tabulate venter. On the body chamber, the primaries divide unevenly, sometimes dichotomously between $2/5$ and $1/2$ whorl height into mostly three weakly prosoradiate secondaries which cross prominently over the venter. The last suture of the more complete specimen shows a slender U_2 and highly raised umbilical elements; the septum is typically bullate with two subequal external and internal 'lateral' saddles. Similarly raised umbilical elements with narrow U_2 are preserved on the penultimate whorl of the other specimen.

The aperture is marked on the internal mold by a strongly

oblique curved constriction at least on the flanks; shell and ventral part of the aperture are not preserved.

Comparison. — This new subspecies is distinguished from *Subkossmatia obscura* Spath [for "*Stephanoceras Opis*" Waagen, 1875, p. 140, pl. 36, figs. 1 a,b; non "*Ammonites Opis*" J. de C. Sowerby] by the somewhat broader whorls (end phragmocone: $H/W \sim 1.07$ vs. ~ 1.27) and the shorter primaries and denser secondaries at least on the body chamber. Contrary to Spath's opinion (1928, p. 212), both have the same coiling. The similar *S. opis* (J. deC. Sowerby) [holotype refigured by Spath, 1928, pl. 38, figs. 2 a,b] appears to be distinguished from *S. obscura* mainly in the more compressed whorls with arched venter and ribs, although no view of the phragmocone venter of *S. opis* was given and its body chamber, where Spath's (p. 211) reported measurements were taken, seems to be slightly crushed; even to Spath (*loc. cit.*) the specific distinction appeared doubtful. The primaries of the outer whorls are more strongly prosocline on the holotype of *S. opis* than on the holotype of *S. obscura*, although the inner whorls appear to be similarly ribbed. These differences may be less significant than the broader whorl section, shorter primaries and denser secondaries of the New Guinea form; however, the authors hesitate to distinguish this form more than at the subspecific level from the obviously very similar Indian forms which cannot here be revised.

A closely affiliated if not identical form from New Guinea was figured by Boehm (1913) under "*Macrocephalites keeuwen-sis* β ". The larger specimen (*op. cit.*, pl. 4, fig. 4) still has most of the oblique aperture with strong constriction and peristomal collar. The fragmentary smaller and more evolute specimen figured under the same name (*op. cit.*, pl. 3, fig. 4) may also belong to this subspecies. The supposed "? *Labyrinthoceras* sp." of Donovan (*in* Visser and Hermes, 1962, p. 55) which was restudied in the Shell collection, Rijswijk, has also the typical costation and septal suture of *Subkossmatia* and a similar whorl section to the new subspecies.

Measurements. —

	Dmm	W%	H%	U%
R.G.M. Leiden, st. 126210				
aperture	88	37.5	36.5	29.5
end phrag.	60	49	46	19.5
st. 126211				
body ch.	84	45	43	c.19
Holotype (from figs. of Boehm; text-fig. 9 enlarged?)				
aperture	c.110	c.36	c.43	c.26
phrag.	c.60	47.5	49	17

Superfamily **PERISPHINCTACEAE** Steinmann, 1890

Family **PERISPHINCTIDAE** Steinmann, 1890

(?) Subfamily '**PSEUDOPERISPHINCTINAE**' Schindewolf, 1925

[= Siemiradzkiinae Westermann, 1958; ? = Grossouvriinae Spath, 1930]

Genus **COBBANITES** Imlay, 1962

The genus *Cobbanites*, based on the type species *C. talkeetnanus* Imlay (1962) was compared by its author with the *Choffatia*-*Siemiradzki* [including *Pseudoperisphinctes*] assemblages of Poland (see Neumayr, 1871) and northwestern Germany (see Westermann, 1958), respectively of Upper Bathonian-Lower Callovian and of Upper Bathonian age. *Cobbanites* was said to be distinguished by the weaker and denser primaries on the body chamber, the more strongly projected secondaries, and to be generally characterized by the strong, projected constrictions which also distinguish it from the otherwise similar *Procerites*. *Cobbanites* is actually a close homeomorph of the Upper Bajocian *Leptosphinctinae*. Because of the absence of a 'coronate' stage, *Cobbanites* is probably best placed in the 'Pseudoperisphinctinae' for which was substituted the name Siemiradzkiinae since the nominate genus *Pseudoperisphinctes* is at best a subgenus of *Siemiradzki* (Westermann, 1958, p. 83); however, the name *Grossouvriina* Spath, 1930, would have priority if *Siemiradzki* and *Grossouvria* are retained in the same subfamily.

All hitherto described species are from the Upper Bathonian to Lower Callovian of western North America.

Cobbanites (?) sp. aff. **C. engleri** (Frebold) 1957 Pl. 51, figs. 3 a,b

Material. — One well-preserved internal mold with incomplete 7/8 whorl body chamber, one side slightly crushed.

Description. — The whorls are evolute and rounded subquadrate becoming slightly compressed on the body chamber. The primaries appear at 2 mm diameter. They soon become strong, almost bladelike and prosoradiate, arising rapidly on the umbilical margin and reaching maximal height at or slightly above mid-flank; here they bear small tubercles and divide into strongly projected secondaries which at least on the ultimate whorl, are medially more or less completely interrupted by a smooth band. On the long body chamber, the primaries weaken and lengthen gradually while tubercles are missing. There are three strong oblique constrictions on the ultimate whorl and possibly also on the inner whorls.

The internal septal suture is preserved at the end of the phragmocone where the sutures are probably somewhat approximated. The complexity is only moderate but this may be due to 'senility.' The E/L saddle is large and bipartite, L somewhat asymmetrically trifid, L/U₂ bifid and much smaller than E/L, while the umbilical elements are small and moderately suspensive.

Comparison. — There is close resemblance to *C. engleri* (Frebold), especially to the paratype from the basal Callovian *Gryphaea* bed of Alberta (Frebold, 1957, pl. 40, fig. 1) of which a plaster cast was kindly supplied by Dr. Frebold. However, *C. engleri* is more compressed and has a more complex septal suture. *C. talkeetnanus* Imlay, from the Upper Bathonian and Lower Callovian of southern Alaska and Montana, differs also by more compressed whorls, larger size and less inclined ribs.

There is also close resemblance to *Leptosphinctes*, especially the subgenus *Vermisphinctes* Buckman which locally abounds in the Upper Bajocian of Europe. While *L. (Vermisphinctes)* agrees in the moderately complex septal suture, its innermost whorls are usually distinguished by being 'coronate' and the ribs less strongly prosocline. Nevertheless, the Leptosphinctinae include a large variety of forms, still difficult to classify and largely homeomorphic with the 'Pseudoperisphinctinae' being separated partly on their age difference.

Measurements.—

	Dmm	W%	H%	U%
near aperture	77	26.5	27.5	49
end phrag.	50	27.5	26	49

(?) Superfamily **PERISPHINCTACEAE**

Family indet., nov. ?

Genus **IRIANITES** Westermann and Getty, n. gen.

Type species.—*Coeloceras moermanni* Kruizinga, 1926.

Genus diagnosis.—Probably dimorphic; inner whorls planulate, evolute, tabulate, primaries with umbo-lateral bullae and mid-lateral tubercles, secondaries subcontinuous; microconch (male) small and not modified, with lappets; macroconch (female) medium-large, becoming strongly inflated and coronate; septal suture simple with reduced U_2 and suspensive sutural elements.

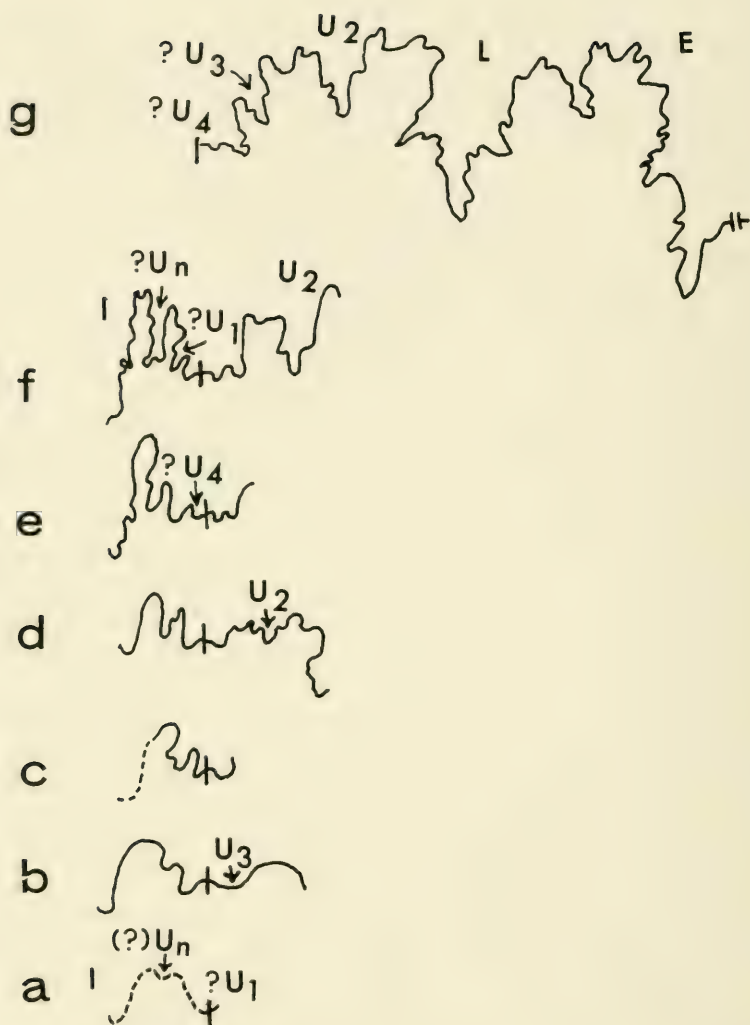
Occurrence.—Indonesia (Sula Is., West Irian, (?) Babar Is.), probably upper Middle Jurassic (M. Bathovian-M. Callovian).

Derivatio nominis.—Pertaining to the abundant occurrence in West Irian.

Remarks.—Although the important stratigraphic evidence regarding the association of the microconchiate *I. moermanni* (Kruizinga) and the macroconchiate dimorphic complement is missing, the resemblance of the inner whorls bearing unusual bituberculate primaries is so striking (Text-fig. 20) that their dimorphic correspondence is strongly indicated. Rather than placing the two forms in different subgenera (and erecting a new 'macroconchiate' subgenus) as has usually been the custom, they are tentatively referred to the same species.

The only known but significant evidence for faunal association is a small fragment of a concretion (Pl. 55, fig. 4) which contains the incomplete lateral impression of a probably macroconchiate *Irianites* together with the partial fragment and impression of a *Bullatimorphites?* (*Treptoceras?*), n. sp. A.; the probable age limit is therefore Middle Bathonian to Callovian.

The microconch of *I. moermanni* has been variously placed in Toarcian '*Coeloceras*' [*Catacoeloceras*] (Kruizinga, 1926; Jaworski, 1933), Lower Pliensbachian *Coeloderoceras* (Arkell, 1956),



Text.fig. 13.—Septal suture morphogeny of *Irianites moermanni* (Kruizinga) ♂, compiled from four specimens from Kemaboe Valley; at whorl height of (a) 0.9 mm. (R.G.M. Leiden, st. 126230), (b) 1.0 mm, (c) 2.0 mm, (d) 2.5 mm. (st. 126213), (e) 3.5 mm (st. 126231), (f) 5.5 mm, and (g) 12 mm (st. 126220).

and Middle Bajocian *Normannites* (Donovan in Visser and Hermes, 1962) and probable *Stephanoceras* (Boehm, 1908); the macroconch of *I. cf. moermanni* has either not been found previously

or, more probably, has usually not been separated from *Stephanoceras s.l.* Previous age estimates for *Irianites* have thus ranged from the early Lower Jurassic to the middle Middle Jurassic, while late Middle Jurassic (incl. Callovian) is now indicated by faunal association.

The taxonomic position of '*Coeloceras*' *indicum* Kruizinga in *Stephanoceras s.l.* (Jaworski, 1933; Arkell, 1956; Donovan, *op. cit.*) is now confirmed; before examining the holotype, the senior author considered it to be the macroconch of *I. moermanni*.

Coeloderoceras Spath is distinguished by ventro-lateral instead of mid-lateral tubercles, the loss of umbo-lateral tubercles or bullae, the somewhat arched venter, and probably the simple aperture. The Dactylioceratidae are similarly distinguished besides having denser ribs, and the umbo-lateral tubercles or bullae are much less prominent if occurring at all.

The stephanoceratid microconch *Normannites* Munier-Chalmas is not tabulate and never bears umbo-lateral bullae or tubercles.

The complete septal suture (Text-fig. 13) with its reduction of U_2 and the adjacent saddles, the deep probable U_n , and its overall simplicity, resembles certain Parkinsoniidae (Upper Bajocian to Lower Bathonian). The U_n modus (originally as "heterochronic U_1 ") of *Parkinsonia* Bayle was observed by Westermann (1956a Abb. 10) and by Schindewolf (1965, pp. 206-212) who, therefore, placed the Parkinsoniidae in the superfamily Stephanocerataceae. However, the fact that in the apparently closely related *Garantiana* Mascke, U_n is usually absent (but present in a few: Schindewolf, 1965, p. 213-218), suggested the restricted taxonomic usefulness of this character, at least regarding higher taxonomic levels. Nevertheless, there is resemblance to the Parkinsoniidae also in the tabulation of the venter, in the tendency to evolute coiling, and finally, in the ribbing with the exception of the umbo-lateral bullae and the ventral continuity. A somewhat similar suture development is also present in the Morphoceratidae which probably include *Asphinctites* Buckman (Schindewolf, 1965, pp. 228-231); however, the umbilical elements of morphoceratids are straight and other features such as constrictions are absent in *Irianites*. There is also superficial resemblance to certain Callovian Kosmocerotidae, in particular to the microconchiate *Toricellites* Buckman and *Gulielmiceras* Buckman which also bear bituberculate primaries; however,

the whole family without known exception has the abullidisculate fluting type of the septum, with two subequal 'internal lateral saddles', and externally, the large L/U_2 saddle and U_2 (Westermann, 1956, pp. 242,265; Schindewolf, 1965, pp. 187-191). In contrast, the septum of *Irianites* is of the modified planulate type such as in the stephanoceratids and in most perisphinctids. There is also some resemblance to certain Reineckeidae (Callovian).

However, as indicated above, identification of U_n in *Irianites* is somewhat tentative. The deep indentation of the primary 'internal lateral saddle' might have originated at its base, which is the flank of (?) U_1 , and could then be considered a part of a bifid U_1 ; this modus is said to be common among the Lower and early Middle Jurassic ammonites as well as among the late Middle and Upper Jurassic Perisphinctaceae (Schindewolf, 1962-66). However, this splitting of U_1 is usually more or less symmetrical and the early sutural elements are much higher in early Jurassic forms; furthermore, Kruizinga's interpretation of the *Irianites* suture bearing a single indented broad 'second lateral saddle' is false; this structure is actually composed of two small saddles enclosing a small U_2 . There is stronger resemblance in the suture to the Perisphinctidae, particularly to their Middle Jurassic representatives which have an inclined inner branch of U_1 according to Schindewolf (1966, p. 332, ff.) (in the 'Pseudoperisphinctinae' originally interpreted as 'heterochronous U_1 ').

The possibility that *Irianites* is a Tithonian or Neocomian berriasellid is excluded through the pre-Kimmeridgian age limitation set by *Bositra buchi* (Roemer) (Pl. 58, fig. 1c).

***Irianites moermanni* (Kruizinga, 1926) ♂**

Pls. 57,58; Text-figs. 13-16, 20-24

- ?1908. *Stephanoceras* aff. *Braikenridgii* J. Sowerby sp., Boehm (Barbar Is.), Neues Jb. Min. Geol. Pal., B.B. 25, p. 330, text-fig. 4, pl. 12, fig. 3 [same specimen as Jaworski, 1933, pl. 11, fig. 8]
 1926. *Cocloceras moermanni* n. sp., Kruizinga (Sula Isl.), Jb. Mijnwezen, vol. 54, p. 44, pl. 13, fig. 2, text-fig. on p. 44.
 1933. *Cocloceras moermanni* Kruizinga 1926, Jaworski (Niederl. Indies), Neues Jb. Min. Geol. Pal., B.B. 70, B, p. 321, text-fig. 6, pl. 11, fig. 1 [holotype refigured].
 ?1933. *Cocloceras* aff. *moermanni* Kruizinga, Jaworski, *id.*, p. 323, pl. 11, fig. 8, text-fig. 7 [same specimen as Boehm, 1908, pl. 12, fig. 3].
 1956. *Cocloceras* ?*moermanni* (Kruizinga), Arkell (World), p. 441.
 1962. *Normannites* cf. *moermanni* (Kruizinga), Donovan in Visser and Hermes (West New Guinea), Verh. Kon. Ned. Geol. Mijnbouw, Genoot, Vol. 20, p. 55, encl. 17, figs. 24 a-c.

Material.—Fifteen more or less complete specimens, several incomplete or juvenile specimens and several fragments (approximately 50 more specimens were retained and only briefly inspected in the Rijksmuseum, Leiden), from the Kemaboc Valley, West Irian. Also two largely crushed specimens from Taliabu, Sula Islands.

Description.—The data for the principal morphological features were plotted in bivariate scatter diagrams (Text-figs. 21-24), together with the corresponding data of the macroconchiate *I. cf. I. moermanni* ♀ (see below).

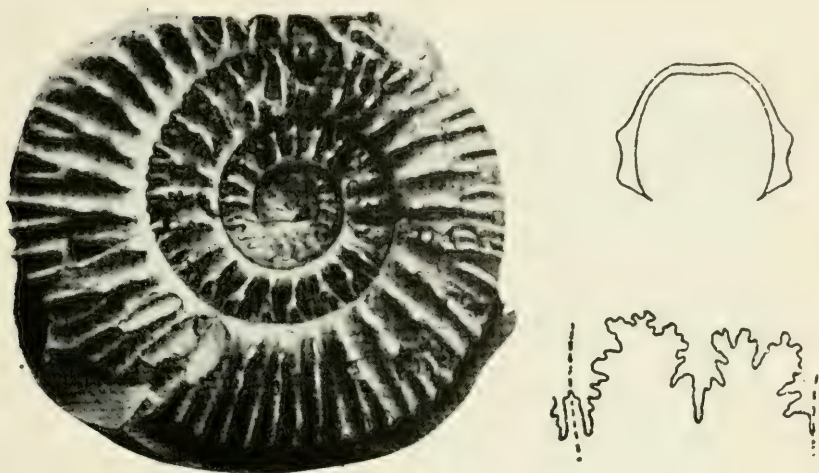
The small microconchiate shell, mostly between 50 and 65 mm (range 45-80 mm) in maximum diameter, is 'serpenticone' throughout with evolute, slowly expanding whorls. The whorl section of the nucleus is depressed oval becoming subcircular at about 8 mm diameter; the intermediate whorls are more or less markedly tabulate; and the outer whorls are subquadrate with narrow steep umbilical wall, flattened sides and venter (Text-fig. 20). The body chamber is $5/8$ to $7/8$ whorls in length, becomes slightly more evolute and terminates in a lappet-bearing aperture. The exact shape of the lappets is unknown but simple spatulate form is suggested. Besides this more common form of about 50-65 mm diameter, there are a few specimens which are distinguished by somewhat larger size of up to 80 mm and slightly more inflated whorls (Pl. 58, figs. 3,4). The largest lappet-bearing specimens (retained in Leiden) measured 80 mm. This less common form is probably a variety rather than a separate taxon (subspecies?), a question that cannot be solved with the available specimens without stratigraphic information. However, this question is of importance since the holotype (see below) appears to belong to this form.

The costation consists of characteristic bulli-tuberculate primaries with peri-umbilical bullae and mid-lateral tubercles, and high sharp secondaries in groups of twos and threes with bullae-like swellings on the shoulders and some weakening over the venter. The described mode of costation is more or less strongly developed at least on the intermediate and outer whorls while the nucleus up to 8-12 mm diameter may be densely and simply costate with bladelike strongly prosoradiate primaries (20-27/whorl) and similar sharp secondaries. Towards the end of the body chamber,

the primaries usually lose bullae and tubercles, again becoming bladelike. Finally, simple bladelike ribs may exceptionally be present, at least on the internal mold, throughout most of the shell (Pl. 57, fig. 4). Some reduction of bullae and tubercles is also present in the larger slightly more inflated specimens.

The mature septal suture (Text-fig. 13 g) is weakly incised with less than average complexity. The morphogeny has been observed commencing at about 3 mm diameter; however, the series of observations is composed from several specimens. At 0.9 mm whorl height (H), the internal suture appears to have a broad single saddle which is weakly indented by a lobe on the outer part of its crest. Slightly later, this lobe is in almost straight to somewhat oblique position dividing a larger inner from a slightly to markedly smaller outer saddle; this element is almost certainly U_n (earlier called "heterochronic U_1 "), rather than a branch of a bifid U_1 . E is broad and deep; the adjacent external saddle is large and broad; L is broad and short-stemmed; the adjacent L/U_2 saddle and U_2 are small, more or less straight, and the following U_2/U_3 saddle is of similar size, the three elements almost appearing as a single broad bipartite saddle. The suture then drops sharply beside the seam to the moderately low, simple (?) U_3 . The small element dorsally adjacent to the seam is probably the reduced U_1 (alternately, no U_3 and U_4 would be developed and all sutural elements would belong to U_1).

Holotype and 'quasi-topotypes'. — The holotype, found *ex situ* in the Sula Islands, was newly described and figured by Jaworski (1933); Jaworski's photograph, his drawing of the body chamber whorl section and measurements, as well as Kruizinga's (1926) original drawing of the septal suture which was verified by Jaworski, are here reproduced (Text-fig. 14). However, the search for the type specimens in the Mineralogical and Geological Museum in Delft where the collection was originally deposited, as well as in the Geological Institute in Amsterdam, where the other type specimens described by Kruizinga are now deposited, was unsuccessful. The holotype was apparently somewhat developed from the matrix by Jaworski enabling him to make more accurate measurements of the last whorl; the body chamber (at about $1/3$ whorl length) is somewhat compressed and not depressed as originally described.



Text-fig. 14.—Holotype of *Irianites moermanni* (Kruizinga) ♂. Lateral view and whorl section reproduced from Jaworski (1933, pl. 7, fig. 7, and text-fig 6); septal suture reproduced from Kruizinga (1926, Text-fig. on p. 44). Approximately $\times 1$.

The end of the phragmocone is marked by several approximated septal sutures (see Kruizinga's original figure) at c. 50 mm D; only $1/3$ whorl of the body chamber is well preserved while about an additional $1/4$ whorl is damaged so that the original maximum diameter was close to 70 mm, approaching the largest specimen described herein. However, none of the body chambers of the New Guinea specimens is as strongly compressed as the holotype ($W/H = 0.8$; Jaworski's measurement). Fortunately, two partly crushed specimens from Tangi, Wai Miha, Taliabu, in the Sula Islands, were found in Brouwer's collection (Geological Inst., Amsterdam, catalogue No. Z 8639) from which the missing holotype was taken. These specimens bear the original labels "*Coeloceras moermanni*" and probably are the ones mentioned in the text by Kruizinga (1926, p. 45, 3 rd. line). The larger one of the 'quasi-topotypes' is here figured (Text-fig. 15). There can be little doubt that these specimens are conspecific with the holotype and with the microconchs described herein from West Irian. Significantly,



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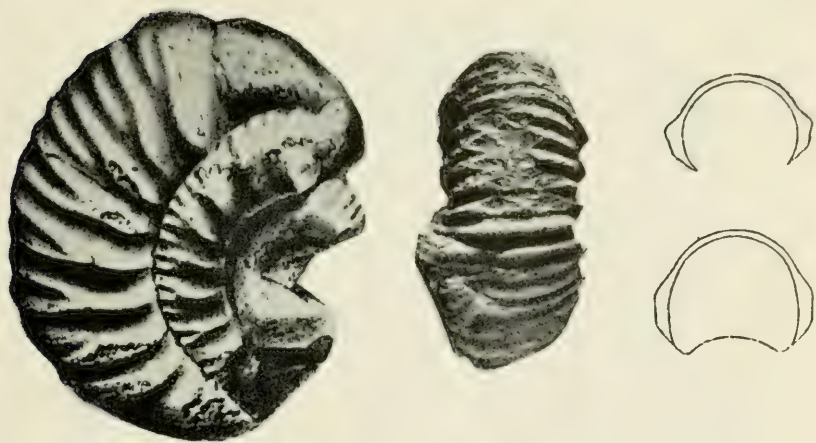


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Text-figs. 15-16. — *Irianites moermanni* (Kruizinga) ♂. 15, 'quasi-topotype' from Tangi, Wai Miha, Taliabu in the Sula Islands. (Geol. Inst., Univ. Amsterdam, Z 8639) x1. 16, specimen from South Geelvink Bay, West Irian (also figured in Visser and Hermes, 1962, encl. 17, figs. 24 a-c) (Shell Res. Lab., Utrecht, s. s. 190 d) x1.

Brouwer's collection from Wai Miha, also includes a single large macroconch (Text-fig. 18) which closely resembles the macroconchiate *Irianites* cf. *I. moermanni* here described from West Irian. Because the search for the holotype is not yet concluded and since the 'quasi-topotypes' are poorly preserved, no lectotype or neotype is now designated.

Comparison and dimorphic correspondence. — The single fragmentary specimen consisting of incomplete body chamber and part of the phragmocone, which was described by Boehm (1908, p. 330, pl. 12, fig. 3, text-fig. 3) from Babar Island, approximately 600 km southwest of New Guinea, was also studied by Jaworski (1933, p. 323, pl. 11, fig. 8, text-figs. 7a,b) and probably correctly placed in close affinity to *I. moermanni*. The photographic reproductions and drawings of this important specimen are here reproduced (Text-fig. 17). According to Jaworski who had the specimens at



Text-fig. 17.—*Irianites* (?) aff. *I. moermanni* (Kruizinga) ♂, from the island of Babar, N.E. of Timor. Side view from Boehm (1908, pl. 12, fig. 3); ventral view and section of ultimate and penultimate whorls from Jaworski (1933, pl. 11, fig. 8 and text-fig. 7a-b). Approximately $\times 1$.

hand, the Babar specimen is distinguished from *I. moermanni* merely by the "absence of the peri-umbilical tubercle-line" (translated from German). However, Jaworski's drawings of the whorl-section indicate that the Babar specimen has bladeliike primaries and more depressed, nontabulate whorls. Generic identity is highly probable, although the Babar specimen appears to belong to a new species.

The striking similarity of the phragmocone with the inner and intermediate whorls of the macroconchiate *Irianites* cf. *I. moermanni* (Text-figs. 20-24) is discussed under the description of the latter form. One cannot help but draw the tentative conclusion that their relationship is that of complementary sexual dimorphs.

Age.—Two incomplete valves and one almost complete valve of *Bositra buchi* (F. A. Rocmer) (1936, pl. 4, fig. 8; original spelling as "*Buchii*") [= *Posidonia alpina* and *P. ornati* auct.] were embedded in the matrix at the aperture of a complete although damaged specimen of *Irianites moermanni* ♂ (R. G. M. Leiden, st. 126217) from Kemaboe Valley. The side view of the ammonite (Pl. 58, fig. 1 a) shows one of the incomplete pyritized valves (the

rest is inside the peristome and could therefore not be prepared); the almost complete valve is shown enlarged (Pl. 58, fig. 1 c) and closely resembles the Bathonian-Callovian specimens recently figured by Jefferies and Minton (1965, pl. 19, figs. 4, 7). According to these authors, who have reviewed much of the previous literature (*op. cit.*, p. 156-157), *B. buchi* ranges from the Toarcian to the Oxfordian and its upper limit coincides with that of the genus and of the entire posidoniid family. This most unambiguous bivalve occurrence therefore significantly restricts the age of *Irianites* — and indirectly that of the *Bullatimorphites*-like forms which were associated with it in a single block — to pre-Kimmeridgian and, probably, post-Pliensbachian.

Measurements. —

	Dmm	H%	W%	U%	P
R.G.M. Leiden, st. 126212					
aperture	55	30	31.5	49	15
body ch.	41.2	30	31	45	12
phragm.	30.5	34.5	34.5	44.5	11.5
"	15	37	40	46	—
"	8.2	29	43	—	—
st. 126200					
body ch.	68.8	29	c.32	47	18
"	60	26	32	49	15
"	52	28	33	49	14
phragm.	45.2	29	32.5	50	13
"	24.5	33	38	46	11
"	13.5	33	45	39	c.11
"	5	40	56	50	c.12
st. 126213					
body ch.	58.0	28.5	31	47	14
phragm.	36.2	26	31.5	43	11
"	19.0	36	c.37	38	10
"	9.6	34.5	42	40	11
"	4.3	42	58	40	—
st. 126215					
aperture	54.5	30.5	30.5	49.5	16.5
"	41	28	27.5	c.48.5	c.13
phragm.	32.5	29	26.5	49	12
"	19.5	31	33.5	38.5	12
st. 126216					
body ch.	51.5	28.5	29.5	50	12.5
"	40	27.5	27	47.5	12
phragm.	30.5	30	26.5	43	11.5
"	15.3	33	33	42.5	12.5
"	7.3	29	46.5	41	—
st. 126217					
aperture	65	26	28	47	14
body ch.	41	29.5	32	44	—



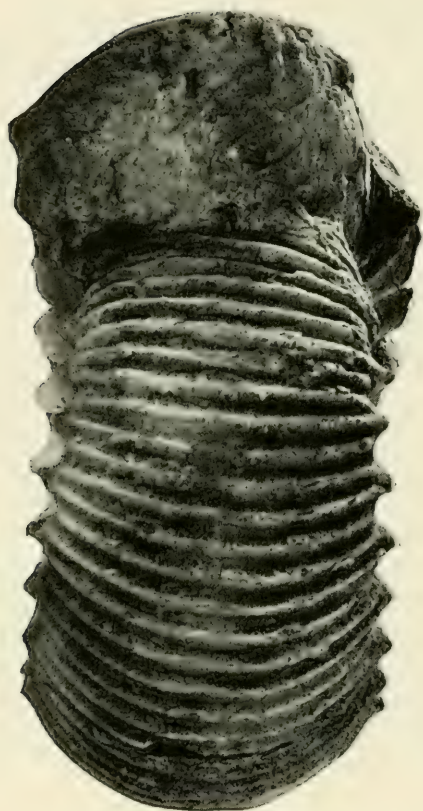
Text-figs. 18a-b. — *Irianites* cf. *I. moermanni* (Kruizinga) ♀, from the Derr-ta section of Wai Miha, Taliabu, Sula Islands. (Rijksmuseum Delft, 14885) x1. (18b: apertural view, see p. 282.)

***Irianites* cf. *I. moermanni* (Kruizinga) ♀**

Pls. 59-62; Text-figs. 19-24

Diagnosis. — Shell large; inner whorls planulate, tabulate, with bituberculate primaries; outer whorl inflated, coronate, *Stemmato-ceras*-to *Teloceras*-like.

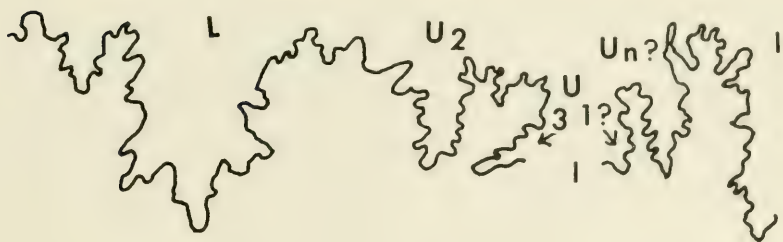
Material. — One well-preserved specimen and at least 20 moderately to poorly preserved partly fragmented specimens; several immature specimens probably identical with this macroconchiate form. All are internal molds with minor test remains without apertures, from the Kemaboe Valley.



Text-fig. 18b (see Text-fig. 18a, p. 281)

Description. — The inner whorls (< 40-55 mm diameter) are evolute with slightly depressed to subcircular section, soon becoming tabulate and somewhat subquadrate. The primaries are bullate at the umbilical edge and tuberculate at mid-flank where they divide into two secondaries with occasional intercalatories. The secondaries are raised on the shoulder and somewhat weakened over the venter which they go straight across.

The outer whorls (> 40-55 mm diameter) become rapidly much more inflated, through positive allometric width growth, and depressed subelliptical in section (Text-figs. 20,21,23); the ventral tabulation weakens or becomes obsolete, finally being lost in the



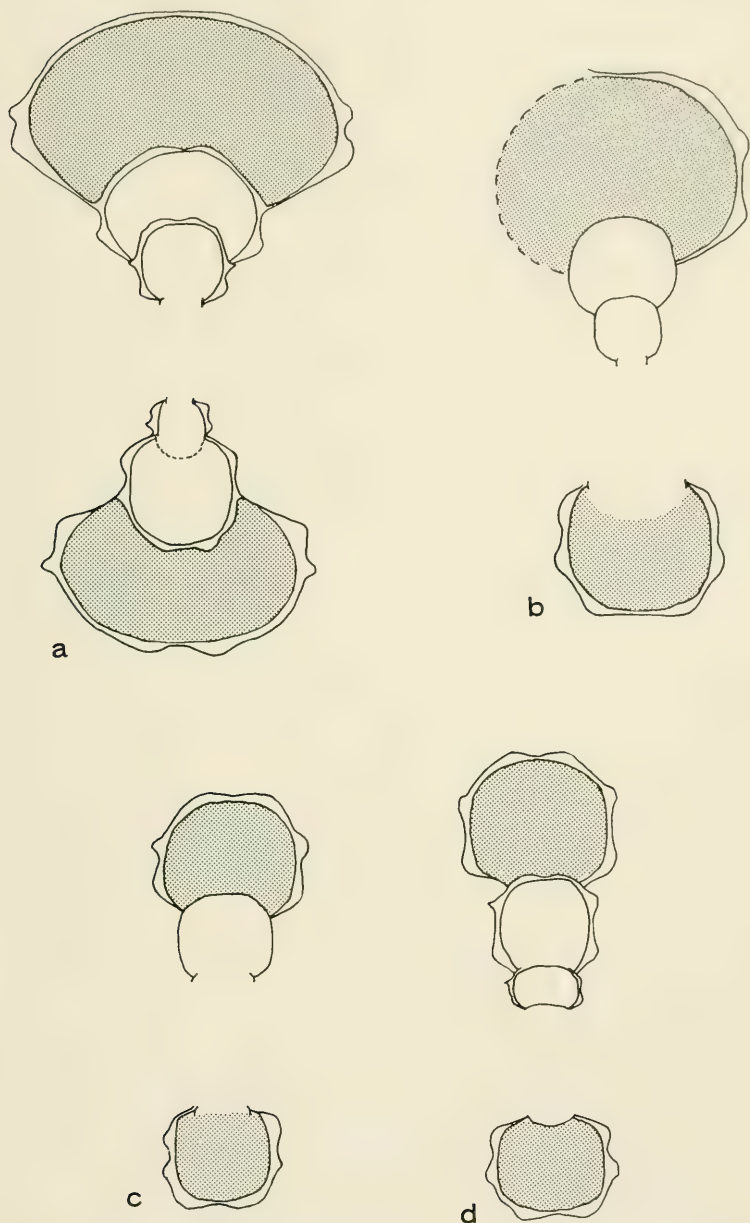
Text-fig. 19. — Adult septal suture of *Irianites* cf. *I. moermanni* (Kruizinga) ♀, at approximately 25 mm whorl height. (R.G.M. Leiden, st. 126222).

largest whorls. The umbo-lateral bullae persist for some time moving somewhat higher on the inner flank, and finally fuse with the lateral tubercles, situated high on the lateral edge, to form short bladeliike ribs. The strong secondaries, in twos with frequent single intercalaries, cross more or less straight and undiminished over the broad venter. The outer $1\frac{1}{2}$ -2 whorls are therefore typically 'coronate'. The body chamber occupies nearly one whorl in the largest more or less complete specimens measuring 80-90 mm diameter, but the aperture is not preserved in any. Taking into consideration several large fragments, the terminal diameter was approximately 90-120 mm.

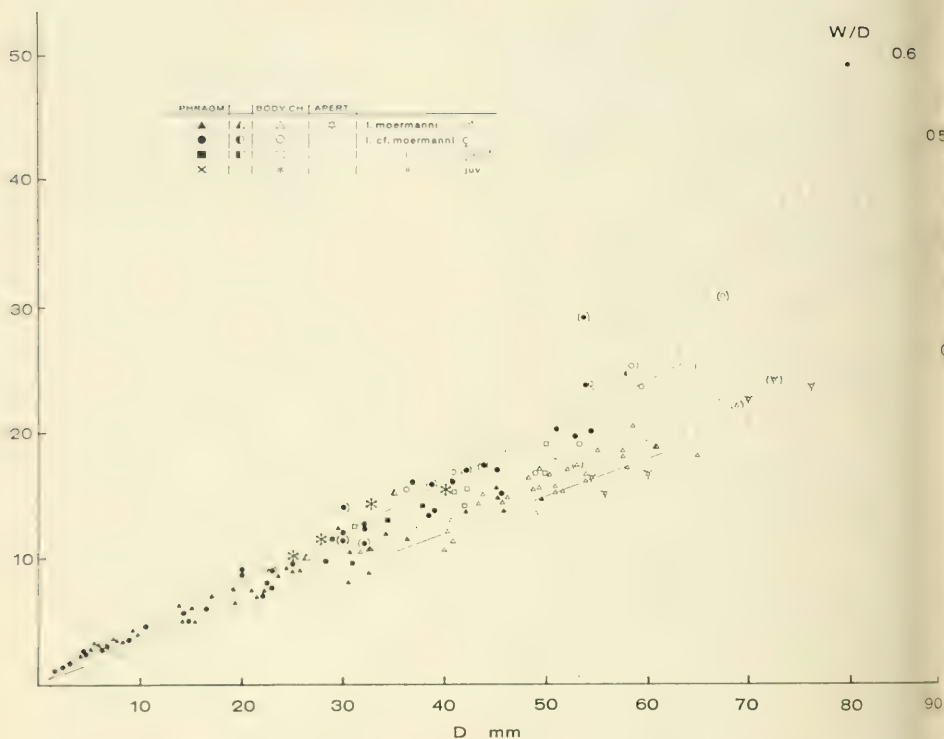
The adult septal suture (Text-fig. 19) is weakly incised only. L is broad and short-rooted; the adjacent simple ('second') lateral saddle L/ U_2 is about as high as the external saddle E/L and only slightly higher but much broader than the oblique 'third lateral' saddle U_2/U_3 , which is separated by the small simple lobe U_2 ; the suture drops sharply adjacent to the umbilical seam with one or two small oblique elements probably belonging to U_3 ; the internal suture consists of a dissimilar saddle pair, the inner one being about twice as large as the outer one, separated by a large almost straight 'internal lateral' lobe ($U_n?$); the lobe adjacent to the seam (? U_1) is approximately as deep as the 'internal lateral' lobe.

Comparison and dimorphic correspondence. — Although superficially resembling *Stemmatoceras* or, if fully grown, *Teloceras* (both probably best classified as subgenera of *Stephanoceras*), this form is clearly distinguished by the planulate and tabulate inner

whorls, the presence of umbo-lateral bullae, and by the simpler septal suture. On the other hand, the inner whorls up to about 50 mm diameter match perfectly the microconchiate *Irianites moermanni* (Kruizinga), described above, in all studied features, *i.e.* whorl section, coiling, costation and septal suture. Although the aperture is not preserved, the modified large outer whorls are certain indicators of macrochonchiate, *i.e.* female, shells. The scatter diagrams (Text-figs. 21-24) for whorl section (W:H), relative width (W:D), relative umbilical width (U:D), and density of primaries (P) of all specimens at hand from Kemaboe Valley, including several immature specimens of intermediate size which could not be assigned to either micro- or macroconch, illustrate this resemblance. Whorl width is negatively allometric for the innermost whorls, becoming approximately isometric for microconchs (δ) and macroconchs (φ) at 20-25 mm D ($W \sim 30$ -40% of D). Thereafter [$> (35)$ 40-55 mm D], however, the macroconchs here described differ strongly from the microchonchiate *I. moermanni* shells: whorl width is now strongly positive allometric up to the end of the conch, while isometry is approximately retained in the microconchs (except for insignificant negative allometry at the end of the body chamber). Since whorl height grows more or less isometric and is similar in both forms (not shown), the plot for whorl section resembles that for whorl width; *i.e.* there is strong positive allometry in the mature macroconchs only, W/H changing from 1.0-1.3 to 1.4-1.8. Growth of umbilical width is isometric and equal in both forms from the innermost whorls to about 45 mm diameter (38-49% of D), but thereafter becomes slightly positive for the body chamber of the microconchs and possibly very weakly negative for the mature macroconchs. The density of primaries (number/whorl) is, again, identical for both forms; the juvenile reduction of density up to 15-25 (30) mm diameter is followed by an increase from about 20-25 primaries per whorl to 27-35 on the mature whorls, although there is possibly a slower increase in the macroconchs. The strong resemblance between both forms clearly indicates dimorphic correspondence. Significantly, a closely related form is also present (Text-fig. 18, 140 mm D) in the Brouwer collection from Wai Miha, Sula Islands (Miner. and Geol. Museum Delft, No. 14885), together with two microconchiate *I. moermanni*



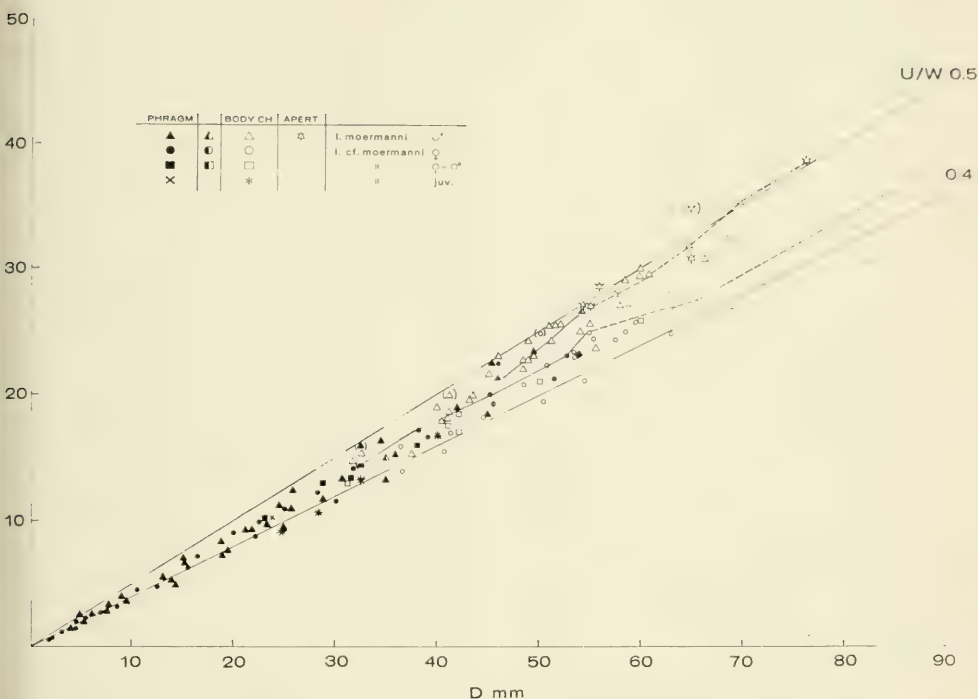
Text-figs. 20a-d.—Cross section of *Irianites*, gray indicating body chamber; a-b, *I. cf. I. moermanni* (Kruizinga) ♀ (R.G.M. Leiden, st. 126221 and 126229); c-d, *I. moermanni* ♂ (R.G.M. Leiden, st. 126212 and 126220). x1.



Text-fig. 21—Scatter of whorl width against diameter (W:D) for *Irianites*, whole collection at hand from Kemaboe Valley; including *I. moerhamni* (Kruizinga) ♂, *I. cf. I. moerhamni* ♀, *I. moerhamni* (?) ♂ or ♀, and *I. moerhamni* juv. For simplicity, no individual growth lines are indicated.

(see above, Text-fig. 15). However, this macroconch has apparently not previously been described or figured.

The single large specimen from the same Brouwer collection of the Sula Islands described by Kruizinga (1926, p. 46, pl. 14, fig. 1) under the new name *Coeloceras indicum* was first believed to be identical with this *Irianites* macroconch. However, the study of the holotype in the Geological Institute, Amsterdam, showed this to be a typical *Stephanoceras* (*Teloceras*); the primaries rise gradually up to the mid-lateral strong tubercles or spines. At the end of



Text-fig. 22.— Scatter of umbilical width against diameter (U:D) for *Irianites*, whole collection at hand from Kemaboe Valley (as in Text-fig. 21). Only two individual growth lines are indicated (body chamber dotted).

the phragmocone, made visible after partial removal of the body chamber, the secondaries are rather blunt and densely spaced. Contrary to Arkell's (1956, p. 440) opinion, the strongly worn body chamber was probably ribbed to the end (Text-fig. 9). The umbilical suture is shown by Kruizinga (1926, fig. on p. 46). *Stenmatoceras etheridgei* Gerth (1927) from New Guinea is probably distinct from *S. indicum*, apparently having less developed primaries and denser secondaries at similar diameter (Text-fig. 8).

Measurements —

	Dmm	H%	W%	U%	P
R.G.M. Leiden, st. 126221					
body ch.	84	31	49.5	43	c.14
"	66	32.5	47	42	—
phragm.	55	32	36.5	46	14
"	38.4	30	34	45.5	13
st. 126229					
body ch.	63.3	31	42	43	14
"	51	31	34.5	43.5	13
phragm.	39	34.5	35.5	43	11.5
"	14.2	42	39	43	13
"	4.6	43.5	54	43.5	—
(L 136) body ch.	54.7	31	43	39	12.5
"	41	34	41	41.5	12
phragm.	32	35	39	45	11.5
"	16.7	31	36	42	10.5
"	6.1	41	46	36	—
"	3	33.5	53	36.5	—
"	1.4	36	71	28.5	—
st. 126228					
body ch.	57.2	32	42.5	42	14.5
phragm.	c.39	c.33	c.41	c.45	13
st. 126224					
body ch.	81	32	41.5	—	—
"	69	33	48	—	—
phragm.	54	33	43	—	—
st. 126223					
body ch.	90	29	46.5	—	—
"	75	31	50	—	—
phragm.	23	28.5	c.39	—	—
st. 126222					
phragm.	c.78	c.38	c.66	—	—
"	c.30	c.35	c.47	—	—

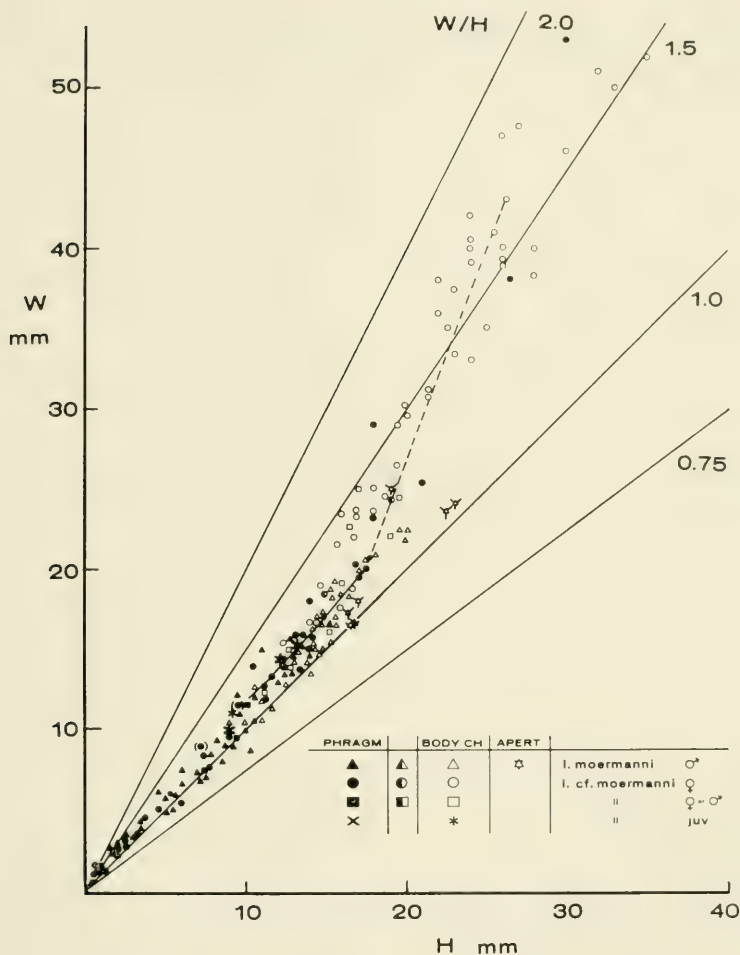
FAUNAL AFFINITIES AND AGES

The Le Roux fossil collection from the Kemaboe Valley, West Irian, is made up of the following Middle Jurassic to basal Cretaceous ammonite species (number of specimens in parenthesis):

Bajocian:

Fontannesia aff. *F. clarkei* (Crick) [subsp. *kiliani* (Kruizinga)]

(7)



Text-fig. 23. — Scatter of whorl section, *i.e.* whorl width against whorl height (W:H), for *Irianites*, whole collection at hand from Kemaboe Valley (as in Text-fig. 21). Only a single individual growth line is indicated (body chamber dotted).

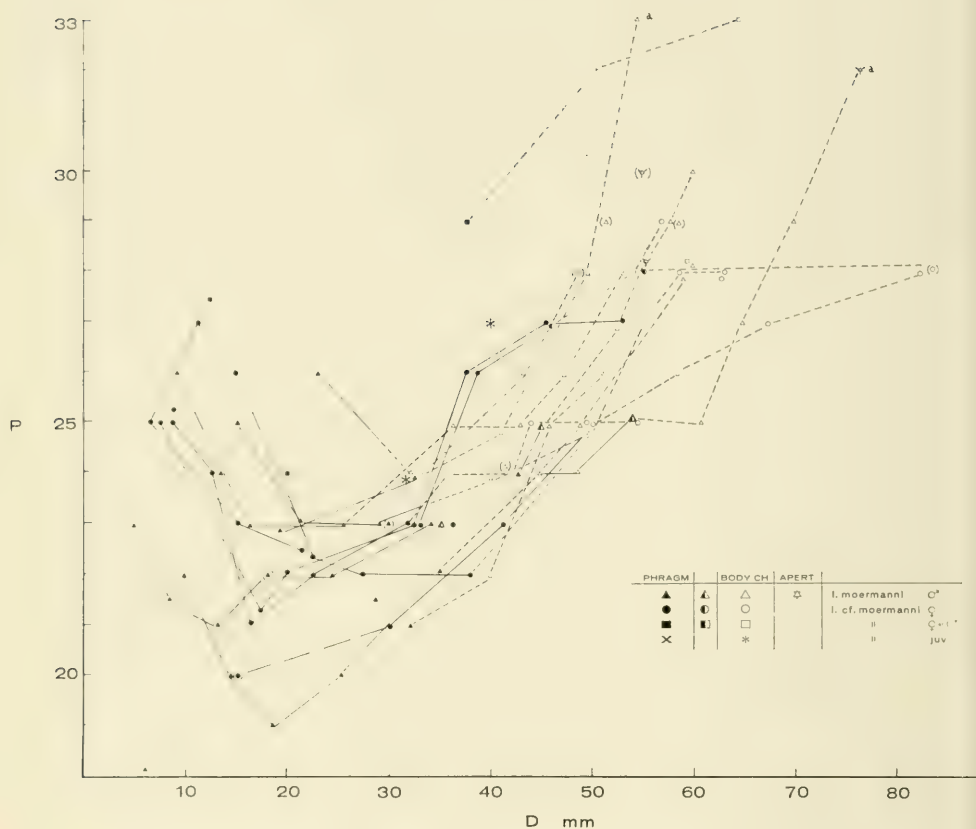
Docidoceras (Docidoceras) longalvum cf. limatum

(Pompeckj) ♀ (1)

D. (D.) sp. indet. (1)

Stephanoceras (Stephanoceras) aff. S. humphriesianum

(J. de C. Sowerby) ♀ (1)



Text-fig. 24. — Scatter of rib density, i.e. primaries per whorl against diameter (P.D.), for *Irianites*, whole collection at hand from Kemaboe Valley (as in Text-fig. 21). Most individual growth lines are indicated (body chamber dotted).

(?) *S. (Stemmatoceras?) etheridgei* (Gerth) ♀ (1)

S. (Stemmatoceras?) etheridgei (Gerth) ?, ♂ [*Itinsaites*] (1)

Bathonian-Callovian:

Bullatimorphites ?, n. sp. ♀ (5-8)

B. (?) (Treptoceras?) aff. B. microstoma (d'Orbigny) ♂ (1)

B. (T.) aff. B. uhligi (Popovici-Hatzeg) ♂ (2-3)

B. (?) (T. ?) costidensus, n. sp. ♂ (c.25)

- B.* (*T.* ?) n. sp. A. ♂ (8)
 (?) *Cobbanites* aff. *C. engleri* (Freebold) [??]
Leptosphinctes] (1)
Irianites moermanni (Kruizinga) ♂ (65-75)
I. cf. *I. moermanni* (Kruizinga) ♀ (25-30)

Callovian:

- (?) *Eucycloceras intermedium* Spath (♂?) (1)
 ? *E.* sp. indet., ♂? (1)
Subkosmatia obscura boehmi, n. subsp. (2)

Upper Tithonian-Valanginian:

- Blanfordiceras wallichi novaguinense* Gerth (2)
B. sp. indet. (4)
Himalayites aff. *H. nederburghi* Boehm (1)
Olcostephanus ('*Rogersites*') sp. indet. (1)

Most of the Lower Bajocian (*s.s.*) to Middle Callovian ammonite species, as well as most genera here described, are either new to Indonesia (including West Irian) or have previously been wrongly classified. *Docidoceras*, *Bullatimorphites* (*Treptoceras*), *Stephanoceras s.s.* and (?) *Cobbanites* are new to the entire south-eastern Asia-Australia area; only *Irianites* appears to be endemic to eastern Indonesia.

Lower Bajocian (Text-fig. 25 a). — *Fontannesia* aff. *F. clarkei* (Crick) may be identical with the dubious '*Grammoceras kiliani*' (Kruizinga) from the Sula Islands, which, if indeed a *Fontannesia*, may best be classified as a subspecies of *F. clarkei s.l.* Significantly, *F.* cf. *F. clarkei* has recently (Bremer, 1966) been described from the lower *S. sowerbyi* Zone of Turkey in the easternmost Mediterranean occurrence of *Fontannesia*. Anatolia appears also to be the only hitherto known occurrence of *Docidoceras longalvum limatum* (Pompeckj) (*op.cit.*) the distribution of which is now tentatively extended to New Guinea. The two species are good indicators for the *S. sowerbyi* Zone, probably its lower part, the *L. discites* Subzone (of Europe) which is also the age of the Anatolian occurrence. This close affinity suggests direct migration from the eastern Mediterranean to New Guinea (wherever it may have been located during Jurassic time). Surprisingly, unquestionable *Docidoceras* has not been reported from the fossiliferous Western Australian



Text-figs. 25a-b.—Known geographic distribution of the Bajocian-Callovian Ammonitina genera and subgenera occurring in the Kemaboe Valley; plotted on a North polar projection of the Recent globe. (25b, see p. 293.)

assemblage of the same age (Arkell, 1954) with the possible exception of the single microconchiate *Docidoceras?* (*Trilobiticeras?*) *depressum* (Whitehouse) and the fragments of '*Otoites* aff. *antipodus*' Arkell (*op. cit.*, pl. 32, figs. 1 a,b).

The supposed American occurrences of *Fontannesia* (Arkell 1956, 1957) are based respectively on a single record without description or figure from British Columbia (Crickmay, 1930)



Text-fig. 25b (see 25a, p. 292)

and probably on the '*Fontannesia austroamericana*' Jaworski (1926) from Mendoza, Argentina, a single probably microconchiate specimen of uncertain affinities. Reliable occurrences of *Fontannesia* are therefore restricted to Europe, Anatolia, Australia, and New Guinea.

The 'reticulate' geographic distribution of *Docidoceras* and closely related Otoitidae was recently discussed (Westermann, 1969, Bull. Amer. Paleont., vol. 57. No. 255). The confirmed distribution of *Docidoceras* s.s resembles that of *Fontannesia*, i. e. Europe, N.W. Africa, Anatolia, and New Guinea, while

records from North America refer either to the southwestern Alaskan *D. (Pseudocidoceras)* or to records from Oregon (Lupher, 1941). However, some early Bajocian stephanoceratids recently described by Imlay (1964) from southeastern Alaska under *Stephanoceras (Skirroceras)* could possibly be *Docidoceras* s.s. [cf. *S. (K.) nelchianus* Imlay, pl. 15, fig. 6, and *S. (K.) juhlei*, pl. 16, fig. 6]. Unfortunately, the complete septal sutures of the best material cannot be investigated because this would mean breaking up type specimens. However, one undescribed specimen of *S. (K.)* cf. *S. nelchianum* (Imlay's identification) from U.S. Geological Survey locality 24120 has a suture intermediate between that of *Docidoceras* and *Stephanoceras* with a dissimilar pair of 'internal lateral' saddles divided by an almost straight U_n ; significantly, the listed assemblage from this locality (Imlay, 1964, Table 12) suggests early Bajocian age ['*Sonninia* cf. *S. nodata* Buckman' = *S. (Alaskoceras)* aff. *S. alaskensis* Westermann; '*S.* cf. *S. patella* Waagen' = *Planammatoceras* cf. *P. benneri* (Hoffmann); '*Witchellia* cf. *laeviuscula* (J. de C. Sowerby)']. Although this species is therefore probably correctly placed in *Stephanoceras* (subgen. *Skirroceras* or *Kumatostephanus*), this early Alaskan stephanoceratid suggests the evolution of the family from evolute *Docidoceras*, *D. longalvum* group, of the Otoitidae.

Middle Bajocian. (Text-fig. 25 a). — *Stephanoceras (Stemmatoceras?) etheridgei* (Gerth), based on an incomplete macroconch (holotype here refigured), is apparently known only from New Guinea and probably distinct from the large but poorly known *S. indicum* (Kruizinga), originally described from the Sula Islands. Probably two of the '*Stemmatoceras*' from the Langgeroe area figured in Visser and Hermes (1962, encl. 17, figs. 16 a,b and 19 a-c) belong to *E. etheridgei* while others resemble closely *S. (Teloceras) itinsae* (figs. 20 a,b), *S. albertense* (figs. 22 a,b) and '*Itinsaites*' *itinsae*, McLearn spp., from the *S. humphriesianum* Zone of the North American Cordilleras. Closely affiliated with *S. (Teloceras) itinsae* (McLearn) and *S. palliseri* (McLearn), also described from the northern Cordilleras, is the Mamâpiri (Langgeroe area) specimen figured by Boehm (1913, text-fig. 3, pl. 3, fig. 2). Significantly a similar specimen has recently also been found in the Malargüe area of Mendoza, Argentina (unpublished).

Of particular interest is the discovery of a typical *Stephanoceras* of the *S. humphriesianum* group which now appears almost cosmopolitan in distribution; *S. caamanoi* (McLearn) is one of possibly several northeastern Pacific representatives and a specimen from north-central Chile has been recorded (Westermann, 1967, p. 68). Several subgenera of *Stephanoceras* which are in part intermediate to *Cadomites* and of early Upper Bajocian age, occur in the Western Interior United States (Imlay, 1961, 1967), Mexico (*S. undulatum* Burckhardt), Chile and Argentina (Steinmann, 1881; Westermann, 1967).

(Upper) Bathonian - (Middle) Callovian. — The larger part of the Kemaboe Valley ammonites appears to be endemic to the eastern Indonesia area and cannot be dated accurately, but is placed with some confidence in this interval. Surprisingly, the collection did not contain a single *Macrocephalites* s.l., probably the most ubiquitous and common group in the whole Indo-West Pacific Callovian. However, the presence of the Middle Callovian eucycloceratids leaves no doubt that this stage is represented.

Of particular interest are several species, all tentatively classified under *Bullatimorphites*, with both macro- and microconch; the genus was previously almost unknown from the circumpacific area, with the single exception of *B. sof anum* (Boehm) from the Sula Islands. All species, however, differ from the typically European-southwestern Asian *Bullatimorphites* in the dense and usually curved ribbing of at least the inner whorls, the more regularly coiled body chamber, and the relatively narrow U_2 lobe. In the costation they resemble the Middle Callovian Eucycloceratinae *Eucycloceras*, *Subkossmatia*, and *Idiocycloceras* which, west of Geelvink Bay and on the Sula Islands appear to be profusely represented but were largely misidentified with *Macrocephalites* spp. (Boehm, 1912, 1913). Significantly, *Bullatimorphites sof anum* (Boehm) and ? *B. (Treptoceras)* sp. have recently also been found in the *M. macrocephalus* Zone of Neuquén in the southern Andes (unpublished).

The most important species for correlation is *B. (Treptoceras)* aff. *B. uhligi* (Popovici-Hatzeg), which also occurs at the Wairori River (Gerth, 1927, p. 226: "*Sphaeroceras* cf. *bullatum* d'Orb."; refigured here for the first time, Text-fig. 10). *B. uhligi* ["*B. sue-*

vicus (Roemer) "auct."] and closely affiliated *B. crimaciense* Enay ["*A. microstoma*", Quenstedt 1886, *non* d'Orbigny] occur in the shaly facies of the Upper Bathonian and Lower Callovian of Europe (Germany, Romania), and "*B. suevicus*" was recorded from the Upper Bathonian of the Pamirs (*vide* Arkell, 1956, p. 403). The single *B. (T.)* aff. *B. microstoma* (d'Orbigny) resembles the Middle to Upper Bathonian European species.

The more abundant new species which are only tentatively placed in *Bullatimorphites*, however, appear intermediate to the Middle Callovian Eucycloceratinae which they resemble except for the much more depressed whorl section. Only the most common form, *B. ? costidensus*, is named although at least three different forms are present.

Morphological affinity with the Eucycloceratinae suggests that most of the tentative *Bullatimorphites* may be phylogenetic intermediates between Tuliitidae and Eucycloceratinae, *i.e.* that the latter subfamily evolved from Tuliitidae rather than from Sphaeroceratinae as assumed previously, a derivation retained only for the Macrocephalitinae (*Macrocephalites s.l.*). This supposition would also imply that this Indonesian *Bullatimorphites ? costidensus* group is among the last if not representing the latest part of the Tuliitidae, and possibly of Middle Callovian age. Such age would also explain the absence in the collection of *Macrocephalites s.l.* (as would, of course, a Bathonian age).

At least in part associated with the *B. ? costidensus* group (same concretion) is the almost certainly dimorphic *Irianites moermanni* (Kruizinga), a species and genus probably endemic to eastern Indonesia-New Guinea. *I. moermanni* is also associated with *Bositra buchi* (Roemer) which has a known vertical range from the Toarcian to the Oxfordian. Another unnamed species probably occurs in undated beds of Babar Island, northeast of Timor (Boehm, 1908; Jaworski, 1933). *Irianites* is somewhat tentatively placed in the Perisphinctaceae and possibly closest affiliated with 'Pseudoperisphinctinae'.

Callovian.—The New Guinean '*Macrocephalites keeuwensis* $\beta\gamma$ ' Boehm (1913, pl. 5, fig. 2), identified by Spath (1924, p. 212) with *Subkossmatia 'beta-gamma'*, closely resembles the Kutch species *Subkossmatia opis* (Waagen) and the closely related *S.*

obscura Spath and is here given the proper name *S. obscura boehmi*, n. subsp. The Sula Islands species *Eucycloceras intermedium* Spath is probably also present. Both forms appear intimately related and the genera are probably best united.

Eucycloceras and *Subkossmatia* are typical of the greater Indian Ocean area, although *Eucycloceras* is also reported from North Africa (Arkell, 1957, p. L 294). In the famous Kutch section, both genera are restricted to the upper *Reineckeia rehmanni* Zone (Spath, 1933, p. 676) which is now placed in the lower but not basal part of the Middle Callovian, equivalent to the higher parts of the northwest European *K. jason* Zone, where *Macrocephalites s.l.* has become extinct (Callomon, 1955).

The perisphinctid (?) *Cobbanites* aff. *C. engleri* (Frebold) resembles this basal Callovian species from Alberta and to a lesser degree, *C. talkeetnanus* Imlay from the Upper Bathonian and Lower Callovian of southern Alaska and Montana.

In summary, — the studied ammonites from the Kemaboe Valley clearly indicate the Lower and the Middle Bajocian (exclusive of Aalenian) and the lower Middle Callovian, while Middle Bathonian-Lower Callovian (probably Upper Bathonian) is tentatively suggested; however, it is possible that only Bajocian and Middle Callovian are present. The faunal affinities are strongly Mediterranean in the Lower Bajocian (*S. sowerbyi* Zone), cosmopolitan, somewhat eastern Pacific in the Middle Bajocian and mainly 'Indic' in the (Middle Bathonian to) Middle Callovian, with weak endemism in the Bajocian and strong endemism in the later faunas.

Considering all Bajocian to Callovian ammonite genera now known from New Guinea (Table 1): Lower Bajocian is represented by *Docidoceras s.s.*, *Fontannesia* and *Pseudotoites*; the Middle Bajocian by diverse *Stephanoceras s.l.* and *Chondroceras*; doubtful Upper Bajocian by *Chondroceras* ? (*Praetulites*) and possibly by *Cadomites* ? [recorded only; but not '*Baculatoceras*' in Visser and Hermes, 1962, which is *Blanfordiceras*]; possible Bathonian by *Tulites* ? [recorded only] and the *Cadomites* ? mentioned above and *Bullatimorphites* of the *B. uhligi* and (?) *B. microstoma* groups; Lower Callovian by diverse *Macrocephalites s.l.*; (lower) Middle Callovian by *Subkossmatia*, *Idiocycloceras*, and *Eucycloceras* (?).

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PLATES

EXPLANATION OF PLATE 48

Natural size if not otherwise indicated

Figure	Page
Fontannesia aff. F. clarkei (Crick) [? subsp. kiliani (Kruizinga)]	238
1a-c. Almost complete specimen, with 2/3 whorl body chamber, last two septa not clearly approximated (R.G.M. Leiden, st. 126181).	
2. Incomplete specimen with 1/2 whorl body chamber (R.G.M. Leiden, st. 126182).	
3a-b. Slightly damaged specimen with partly preserved aperture, body chamber of 2/3 whorl, last septa not markedly approximated. (R.G.M. Leiden, st. 126183).	
4a-b. Small, probably immature specimen, body chamber and crushed phragmocone (R.G.M. Leiden, st. 126184).	



1a



1b



1c



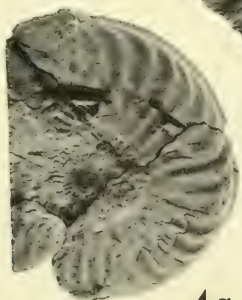
2



3a



3b



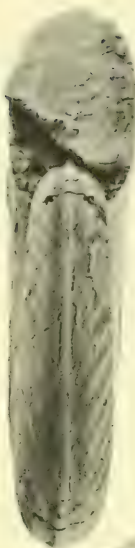
4a



4b



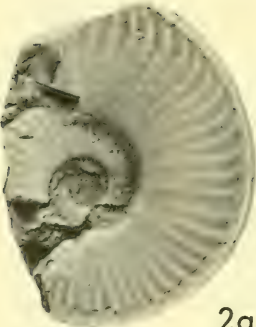
1a



1b



1c



2a



2b



3a



4a



4b



3b

EXPLANATION OF PLATE 49

Natural size if not otherwise indicated

Figure	Page
Fontannesia aff. F. clarkei (Crick) [? subsp. kiliani (Kruizinga)]	238
1a-c. Wholly septate specimen, last septa approximated, with well- preserved nucleus (Text-fig. 4) (R.G.M. Leiden, st. 126185).	
2a-b. Probably not fully grown specimen, compressed, and weakly ornate, with 1/2 whorl incomplete body chamber (R.G.M. Leiden, st. 126186).	
3a-b. Incomplete specimen with 1/2 whorl body chamber, phragmocone partly crushed, with approximated last sutures; b, nucleus of same (R.G.M. Leiden, st. 126187).	
4a-b. Immature (?), probably almost complete specimen with 2/3 whorl body chamber (R.G.M. Leiden, st. 126188).	

EXPLANATION OF PLATE 50

Natural size if not otherwise indicated

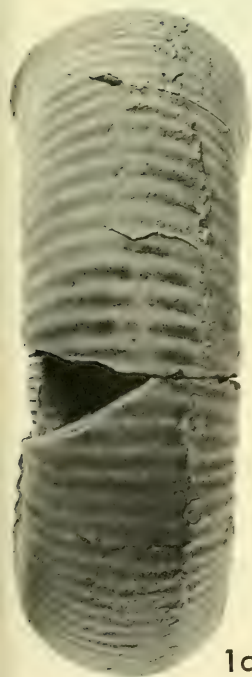
Figure	Page
1a-d. Docidoceras (Docidoceras) longalvum (Vacek) cf. subsp. limatum (Pompeckj) ♀ Complete specimen with aperture; note umbolateral groove with porous filling (R.G.M. Leiden, st. 126189).	244
2. (?) Docidoceras (Docidoceras) sp. indet. ♀ Incomplete body chamber and remnants of penultimate whorl (R.G.M. Leiden, st. 126190).	246



1a



1b



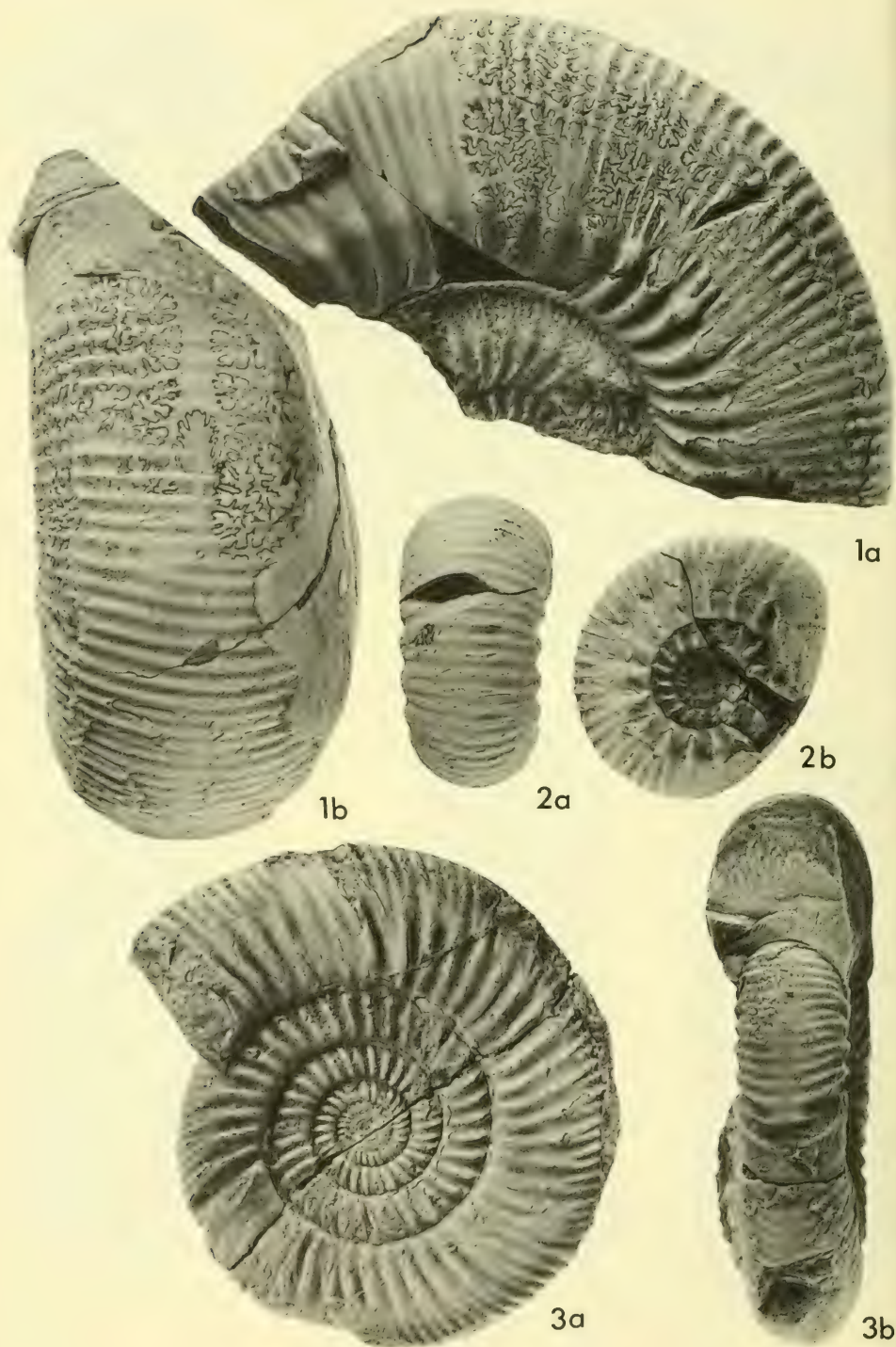
1c



1d



2



EXPLANATION OF PLATE 51

Natural size if not otherwise indicated

Figure	Page
1a,b. Stephanoceras (Stephanoceras) aff. S. humphriesianum (J. de C. Sowerby) ♀	247
Fragment of phragmocone with damaged beginning of body chamber. (R.G.M. Leiden, st. 126191).	
2a,b. Stephanoceras (Stemmatoceras?) etheridgei (Gerth) ?, ♂ ?	252
Probably almost complete specimen with 2/3 whorl body chamber (R.G.M. Leiden, st. 126192).	
3a,b. Cobbanites (?) aff. C. engleri (Frebold)	269
Almost complete specimen with 7/8 whorl body chamber. (R.G.M. Leiden, st. 126193).	

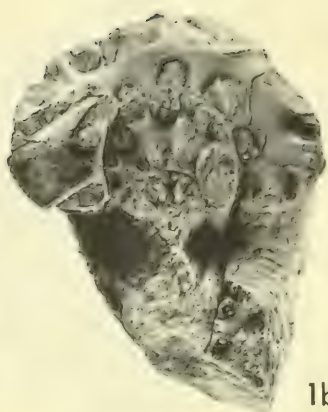
EXPLANATION OF PLATE 52

Natural size if not otherwise indicated

Figure	Page
Bullatimorphites ?, n. sp. ♀	254
1a,b. Somewhat crushed phragmocone with beginning of body chamber (R.G.M. Leiden, st. 126194).	
2a-c. Undistorted phragmocone with 1/4 whorl incomplete body chamber (R.G.M. Leiden, st. 126195).	
3. Fragment of large body chamber with remnant of penultimate whorl (R.G.M. Leiden, st. 126196).	



1a



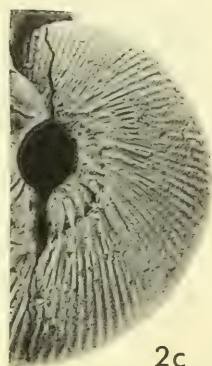
1b



2a



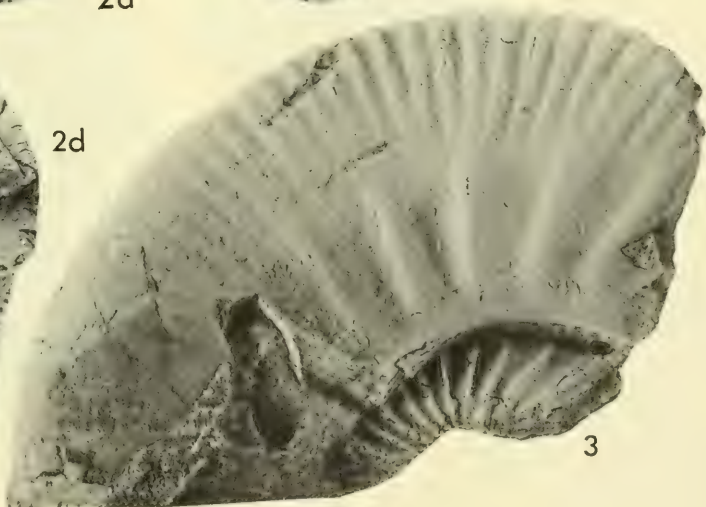
2b



2c



2d



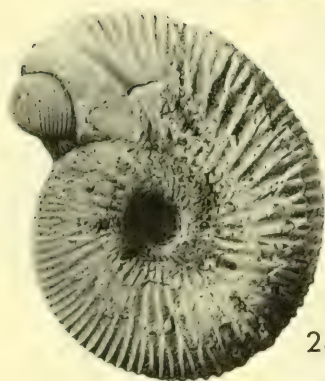
3



1a



1b



2a



2b



2c



3a



3b

EXPLANATION OF PLATE 53

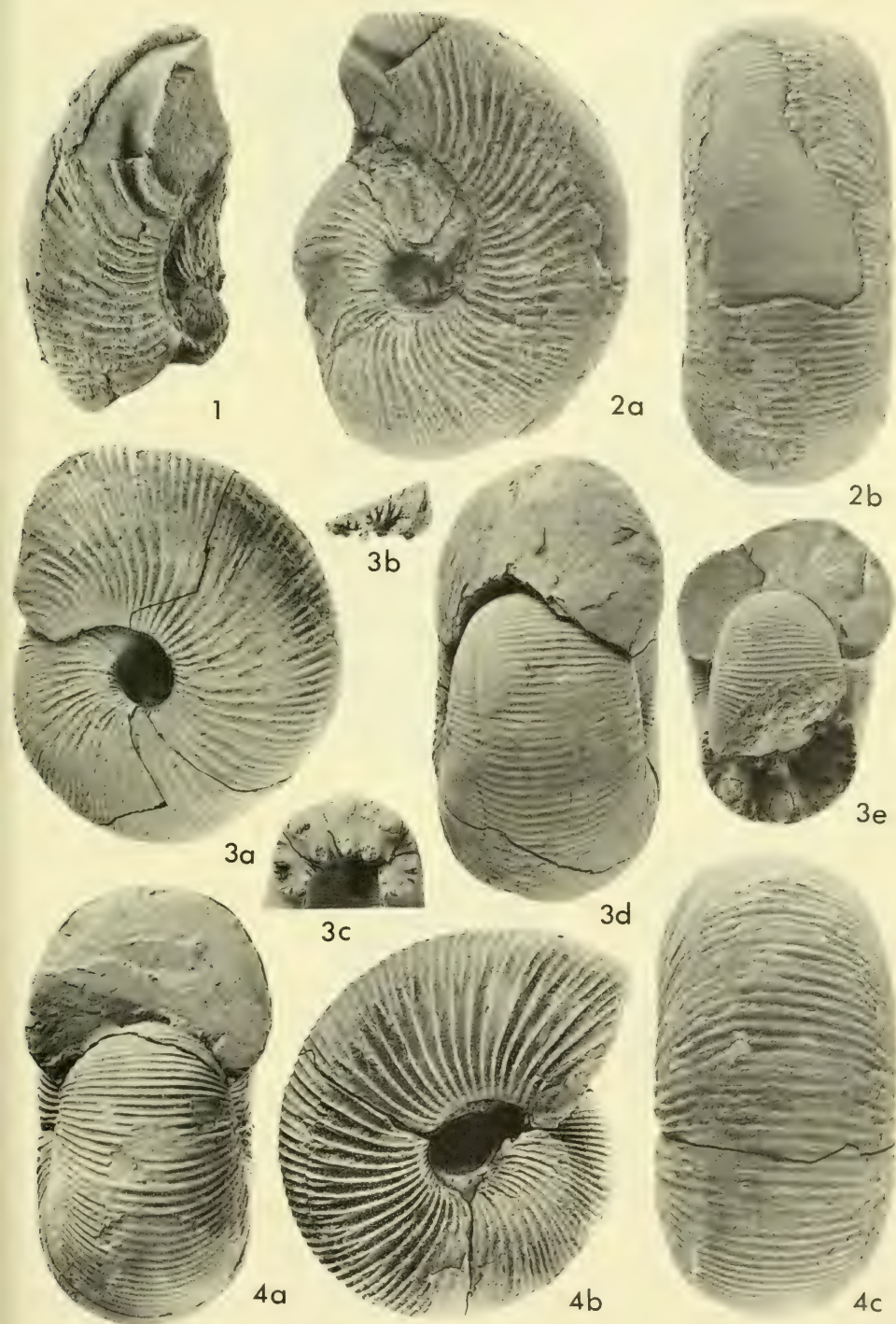
Natural size if not otherwise indicated

Figure	Page
1a,b. Bullatimorphites (Treptoceras) aff. B. uhligi (Popovici-Hatzeg) ♂	259
Specimen with aperture, beginning of body chamber damaged, with ventral costae anomaly (R.G.M. Leiden, st. 126197).	
2a-c. Bullatimorphites (?) Treptoceras ?) aff. B. microstoma (d'Orbigny) ♂	257
Complete, slightly damaged specimen with exposed part of penultimate whorl (R.G.M. Leiden, st. 126199).	
3a-b. Bullatimorphites (Treptoceras) aff. B. uhligi (Popovici-Hatzeg)	259
Incomplete whorl of contracting body chamber with end of phragmocone (R.G.M. Leiden, st. 126198).	

EXPLANATION OF PLATE 54

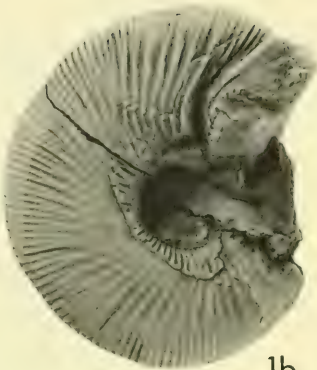
Natural size if not otherwise indicated

Figure	Page
Bullatimorphites ? (Treptoceras?) costidensus Westermann and Getty, n. sp. (♂ ?)	260
1. End of body chamber with probably incomplete aperture (R.G.M. Leiden, st. 126200).	
2a,b. Complete but somewhat deformed body chamber with incomplete aperture (R.G.M. Leiden, st. 126201).	
3a-e. Holotype, almost complete body chamber of over one whorl and part of phragmocone; b,c, lateral and apertural views of last septum; e, part of body chamber removed (R.G.M. Leiden, st. 126203).	
4a-c. Almost complete body chamber of one whorl (R.G.M. Leiden, st. 126202).	





1a



1b



1c



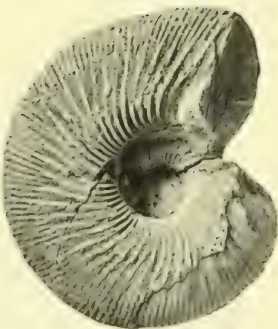
2a



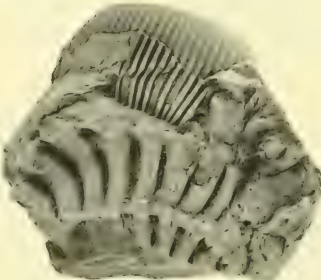
2b



1d



3



4a



4b

EXPLANATION OF PLATE 55

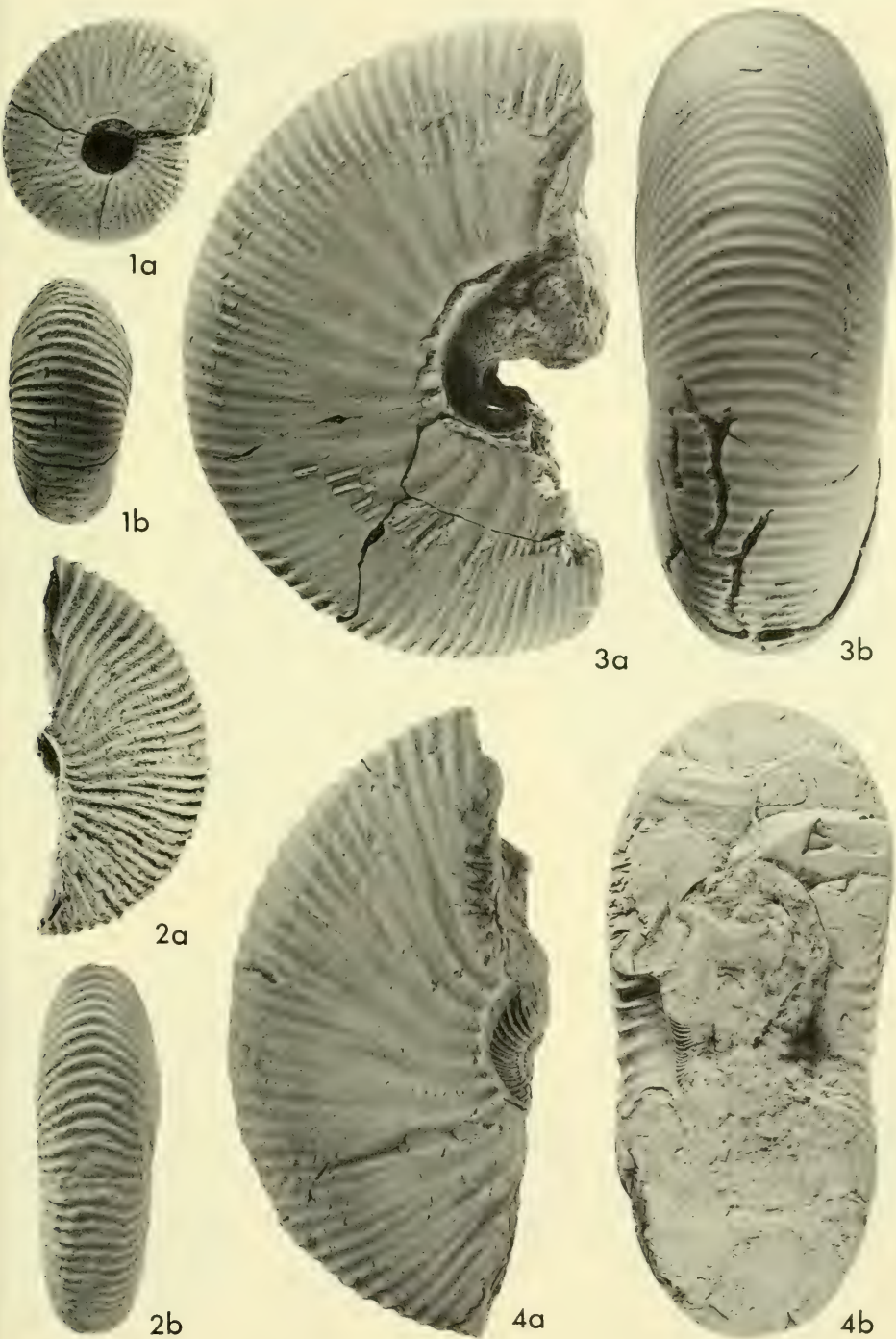
Natural size if not otherwise indicated

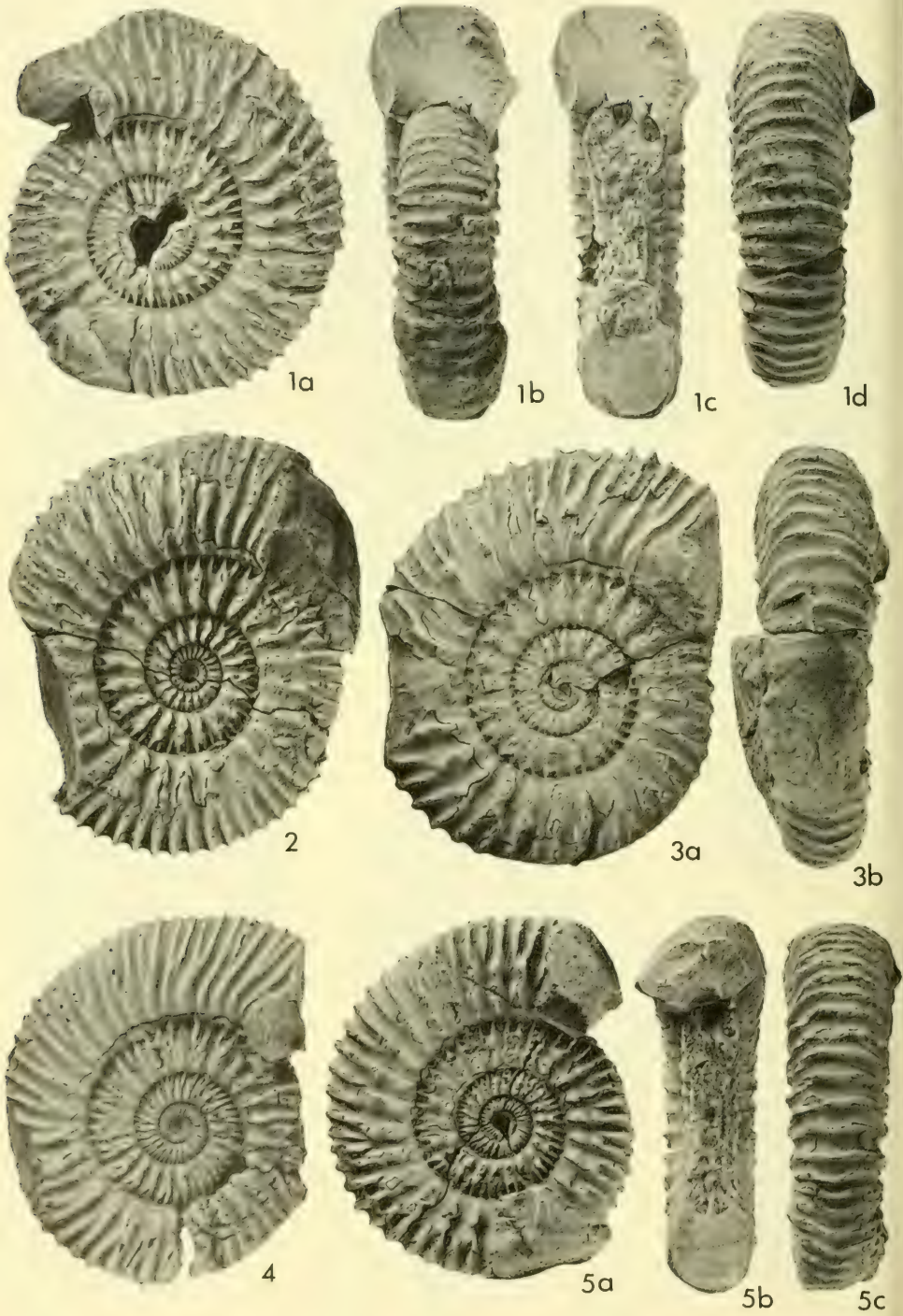
Figure	Page
Bullatimorphites ? (Treptoceras?), n. sp. A ♂	262
1a-d. Complete body chamber with aperture (lappets) and phragmocone, right side damaged and distorted (R.G.M. Leiden, st. 126204).	
2a-b. Almost complete specimen (R.G.M. Leiden, st. 126205).	
3. Almost complete body chamber with parts of crushed phragmocone, secondaries exceptionally dense (R.G.M. Leiden, st. 126206).	
4a-b. Rock fragment with impression of <i>Irianites</i> cf. <i>moermanni</i> (Kruizinga) and <i>B.?</i> (<i>T.?</i>), n.sp. A.; b, latter species after removal of former, composed of body chamber fragment and plasticine mold of inner whorls (R.G.M. Leiden, st. 126207).	

EXPLANATION OF PLATE 56

Natural size if not otherwise indicated

Figure	Page
1a-b. ? Eucycloceras sp. indet., ♂ ?	266
Somewhat distorted specimen with approximately 1/2 whorl body chamber (R.G.M. Leiden, st. 126208).	
2a-b. (?) Eucycloceras intermedium Spath, ♂ ?	265
Incomplete 1/2 whorl body chamber and part of penultimate whorl (R.G.M. Leiden, st. 126209).	
3,4. Subkossmatia obscura Spath boehmi Westermann and Getty, n.subsp.	266
3a,b, almost complete body chamber and part of penultimate whorl (R.G.M. Leiden, st. 126210). - 4a,b, incomplete body chamber with remnants of inner whorls (R.G.M. Leiden, st. 126211).	





EXPLANATION OF PLATE 57

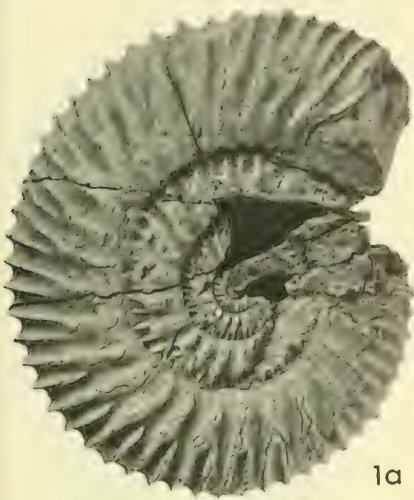
Natural size if not otherwise indicated

Figure	Page
Irianites moermanni (Kruizinga) ♂	274
1a-d. Nearly perfect specimen with incomplete aperture (base of lappets), nucleus damaged; b,c, part of aperture removed to show whorl section (R.G.M. Leiden, st. 126212).	
2. Almost complete adult specimen (approximated sutures) with damaged incomplete, almost 3/4 whorl body chamber (R.G.M. Leiden, st. 126213).	
3a,b. Probably complete specimen except for aperture, with 3/4 whorl body chamber (R.G.M. Leiden, st. 126214).	
4. Complete specimen with base of lappets, approximated sutures and 2/3 whorl body chamber (R.G.M. Leiden, st. 126215).	
5a-c. Probably complete specimen except for aperture, with 3/4 whorl body chamber and most of the test preserved (R.G.M. Leiden, st. 126216).	

EXPLANATION OF PLATE 58

Natural size if not otherwise indicated

Figure	Page
Irianites moermanni (Kruizinga) ♂	274
1a-c. Complete body chamber of 7/8 whorl (? base of lappets) with damaged phragmocone; c, <i>Bositra buchi</i> (F.A. Roemer) [<i>Posidonia</i> auct.] at aperture of same specimen, $\times 2$. (R.G.M. Leiden, st. 126217).	
2a,b. <i>Irianites</i> sp. juv. with 2/3 whorl incomplete body chamber (R.G.M. Leiden, st. 126218).	
3a,b. Body chamber fragment with lappets of large inflated form (R.G.M. Leiden, st. 126219).	
4a,b. Almost complete specimen with 3/4 whorl body chamber and approximated sutures; large inflated form (R.G.M. Leiden, st. 126220).	



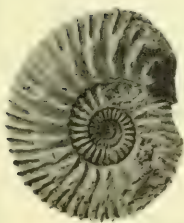
1a



1b



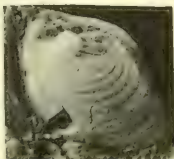
3a



2a



2b



1c



3b



4a



4b



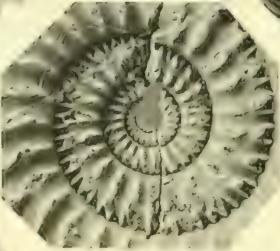
4c



1a



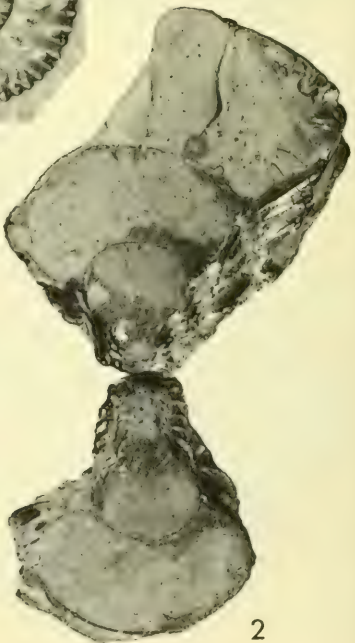
1b



1d



1c



2

EXPLANATION OF PLATE 59

Natural size if not otherwise indicated

Figure	Page
Irianites cf. I. moermanni (Kruizinga) ♀	281
1a-d. Slightly damaged but almost complete specimen with 3/4 whorl preserved body chamber; d, nucleus of same, $\times 1.5$ (R.G.M. Leiden, st. 126221).	
2. Cross-section of fragment of largest phragmocone in collection (R.G.M. Leiden, st. 126222).	

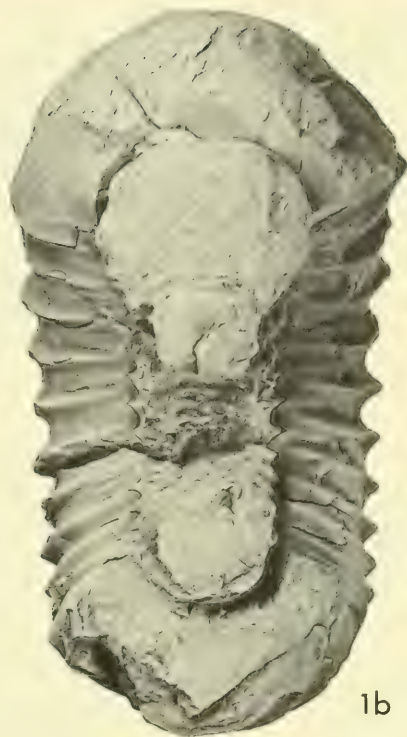
EXPLANATION OF PLATE 60

Natural size if not otherwise indicated

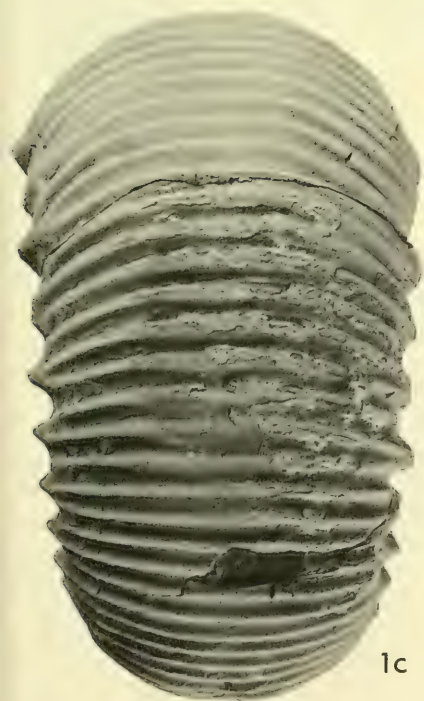
Figure	Page
Irianites cf. I. moermanni (Kruizinga) ♀	281
1a-c. Incomplete specimen with 1/2 whorl preserved body chamber and parts of phragmocone (R.G.M. Leiden, st. 126223).	
2. Almost full whorl (7/8) of incomplete body chamber, partly crushed, and parts of phragmocone (R.G.M. Leiden, st. 126224).	



1a



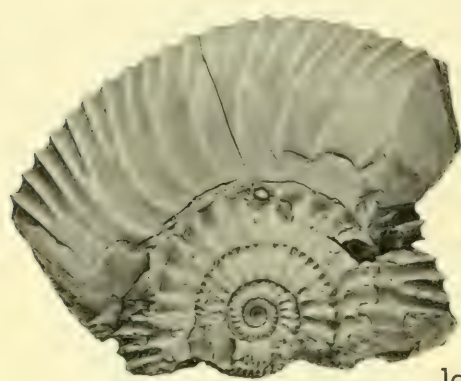
1b



1c



2



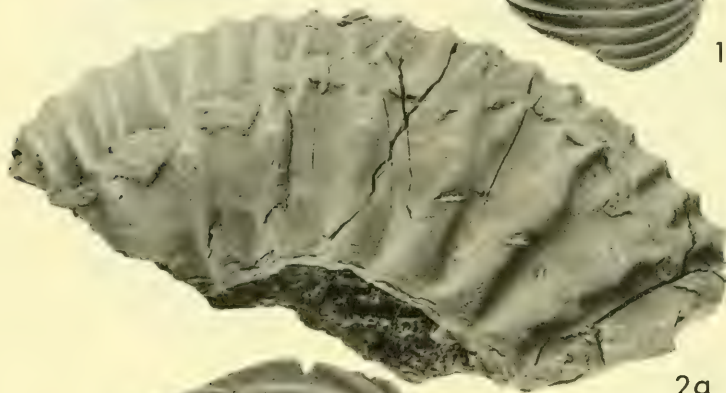
1a



1b



1c



2a



2b



3a



3b

EXPLANATION OF PLATE 61

Natural size if not otherwise indicated

Figure	Page
Irianites cf. I. moermanni (Kruizinga) ♀	281
1a-c. Damaged phragmocone with 1/4 whorl fragment of body chamber (R.G.M. Leiden, st. 126225).	
2. Large body chamber fragment (R.G.M. Leiden, st. 126226).	
3a-b. ? Juvenile ♀, with full one whorl body chamber which is probably complete on left side; b, $\times$ 0.9 (R.G.M. Leiden, st. 126227).	

EXPLANATION OF PLATE 62

Natural size if not otherwise indicated

Figure	Page
Irianites cf. I. moermanni (Kruizinga) ♀ juv.	281
1a-c. Immature specimen with one full whorl incomplete body chamber (R.G.M. Leiden, st. 126228).	
2a-f. Immature specimen with one full whorl incomplete body chamber; d, f, inner whorls of same, x2 (R.G.M. Leiden, st. 126229).	



1a



1b



1c



2a



2b



2c



2d



2e



2f

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Note. Light face type refers to page numbers. Bold face type refers to plate number.

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